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Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

NSP-62-43-Rev 2

LAUNCH OPERATIONAL TEST PLAN

Section 1: Checkout and Launch Plan

Report No. 505, Contracts NAS 8-5600 and NAS 8-9500

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FOREWORD

This revision is submitted as required by Report 505 in the Data Submittal Document, NSP-63-22. Previously listed as Report 501 in Data Submittal Document NSP-62-22, the Checkout and Launch Plan is now Section 1, of Launch Operational Test Plan; which is Report 505 in Data Submittal Document NSP-63-22.

The Checkout and Launch Plan is a planning aide covering typical operations for all flights. Sequence of events from receipt of stage through launch are included. Activities in each functional checkout area, including time spans and schedules are detailed. In addition data requirements, data acquisition, command systems functions, range support and post flight operations are described.

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ABBREVIATIONS

AGC	Aerojet General Corporation
AMR	Atlantic Missile Range
AEC	Atomic Energy Commission
CART	Condition of Assembly For Release and Transfer
C/O	Checkout
DDAS	Digital Data Acquisition System
ESE	Electrical Support Equipment
GFE	Government-Furnished Equipment
GETS	Ground Equipment Test Set
GSE	Ground Support Equipment
IU	Instrument Unit
LCC	Launch Control Center
LMSC	Lockheed Missiles & Space Company
LOC	Launch Operations Center
LVOD	Launch Vehicle Operations Division
LUT	Launch Umbilical Tower
MILA	Merritt Island Launch Area
MSFC	Marshall Space Flight Center
NAB	Nuclear Assembly Building
NASA	National Aeronautics & Space Administration
NRDS	Nuclear Rocket Development Station
NSP	Nuclear Space Programs
NVPO	Nuclear Vehicle Projects Office
QA	Quality Assurance
RCA	Radio Corporation of America
RIFT	Reactor-In-Flight-Test
SNPO	Space Nuclear Propulsion Office
VAB	Vertical Assembly Building

Section 1

INTRODUCTION

The RIFT Program will provide an evaluation of operating characteristics and problems of nuclear rocket propulsion in a space-flight environment. The RIFT stage will be flight-tested as a potential third stage of an advanced Saturn vehicle.

Flight test program objectives as listed in the RIFT Integrated Test Plan are:

1. Evaluate the operation and characteristics of the NERVA engine system during all phases of flight.
2. Demonstrate the structural integrity of the NERVA engine system during the launch, boost and RIFT stage flight phases.
3. Demonstrate safe NERVA engine conditions during all NAB, VAB, mobile arming tower, launch pad, flight and post flight test phases to satisfy all nuclear safety and range requirements.
4. Evaluate the RIFT stage systems, subsystems and components during all phases of inspection, checkout and test at the NAB, VAB, mobile arming tower and launch pad to verify stage flight readiness and compatibility with RIFT vehicle systems.
5. Evaluate operation of the RIFT stage integrated systems, systems, subsystems and components including performance, dynamics, guidance and control action and compatibility with both booster stages from launch through flight termination.
6. Demonstrate satisfactory and safe RIFT stage prelaunch and launch operations capability including compatibility with all GSE.

This document presents preliminary information on operations and support requirements for the nuclear stage from initial receipt through assembly, checkout, launch, flight operations and post-flight operations.

Section 2

FLIGHT PROGRAM

The RIFT flight program will be conducted at MILA. Four RIFT vehicles incorporating live S-N stages and dummy second stages are to be launched. The RIFT vehicle systems breakdown is shown in Fig. [redacted]. 2-1.

3.1. NUCLEAR ENGINE OPERATING CYCLES

A single-thrust cycle of 600 seconds at 100% power with a controlled shutdown is planned for the first flight. The second flight will be identical except for 1200 seconds at 100% power. Two cycles of 100% power (500 seconds and 60 seconds) with controlled shutdown are planned for the third flight. Planning for the fourth flight incorporates a throttling from 400 seconds at 100% power to 60 seconds at 50% power, followed by 60 seconds at 100% power, then up to 110% power for 60 seconds, back down to 100% power for 60 seconds and terminating in a hard shutdown.

3.2. FLIGHT TRAJECTORIES

The flight trajectories are presently undergoing study, and the planned trajectories and impact areas will be presented at a later date [redacted] in Section 4, Support Requirements, of the basic document. All test flights are currently planned for lob trajectories out of MILA for safe disposal in preselected deep-ocean areas. Selection has not been finalize; therefore launch azimuth is not given. A pictorial view of a typical dual thrust trajectory is shown in Fig. 2-2. Nominal trajectories for the first three flights including 100% power cycles referenced to time and ground range are shown in Fig. 2-3.

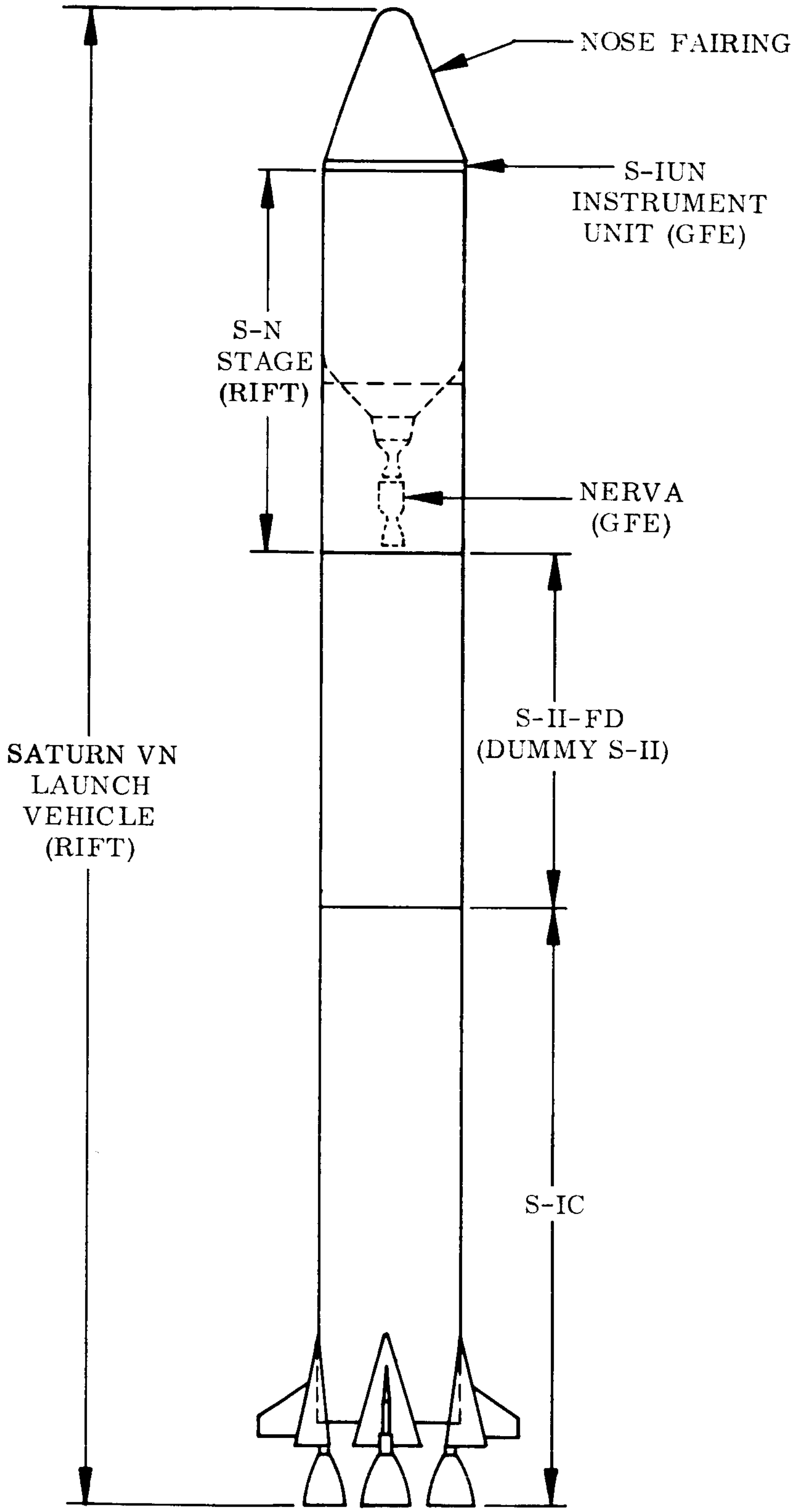

Fig. 2-1 Saturn Launch Vehicle (RIFT) System

Section 3

CONTRACTOR RESPONSIBILITY

Lockheed Missiles & Space Company is the prime contractor for the Saturn nuclear stage. The Aerojet-General Corporation will provide the NERVA engine, with the reactor provided by Westinghouse Electric Corporation.

Overall stage assembly and integrated checkout will be the responsibility of LMSC.

3.1. LOCKHEED NUCLEAR SPACE PROGRAM

Nuclear Space Programs under Space Programs Division, an operating division of Lockheed Missiles & Space Company, will be responsible - under the direction of the responsible NASA Organization - for operations in the Nuclear Assembly Building at MILA to perform the following:

a. Assemble and check out the S-N stage less engine and interstage.

b. Install in the S-N stage a nuclear engine provided by Aerojet-General.

c. Check out the S-N stage less interstage mechanically mated.

d. Deliver the S-N stage less interstage, nose firing and interstage to LOC in accordance with a schedule previously agreed upon.

e. Determine and provide to NASA the requirements for the Nuclear Assembly Building and other RIFT-peculiar requirements of the remainder of Launch Complex 39.

f. Manage the Nuclear Assembly Building, subject to direction of the responsible NASA Organization and, as stage integration contractor, coordinate and direct the activities of Aerojet-General in operations following delivery of the S-N stage to VAB and until the completion of the flight operation.

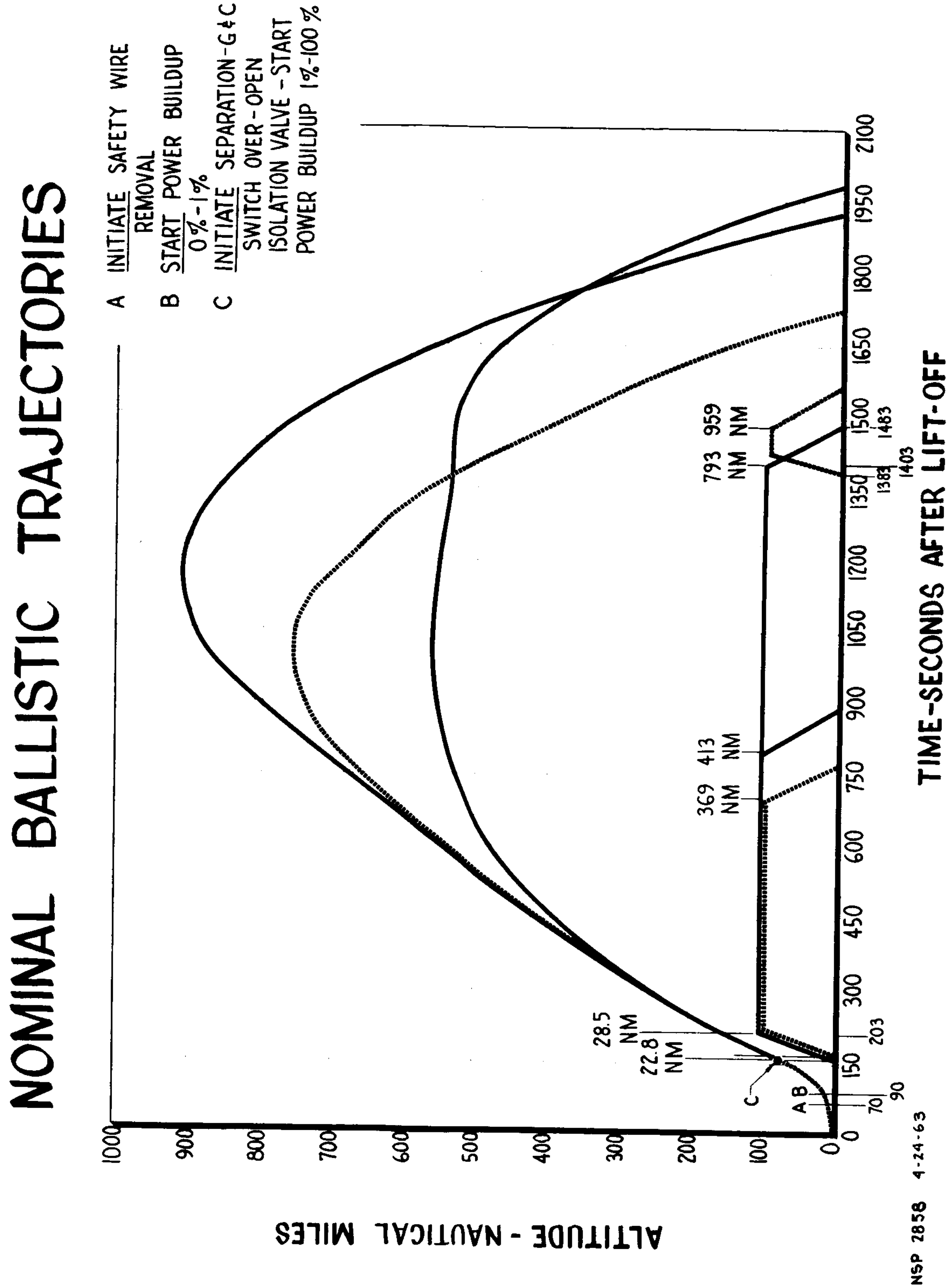

Fig. 2-3 Nominal Ballistics Trajectories

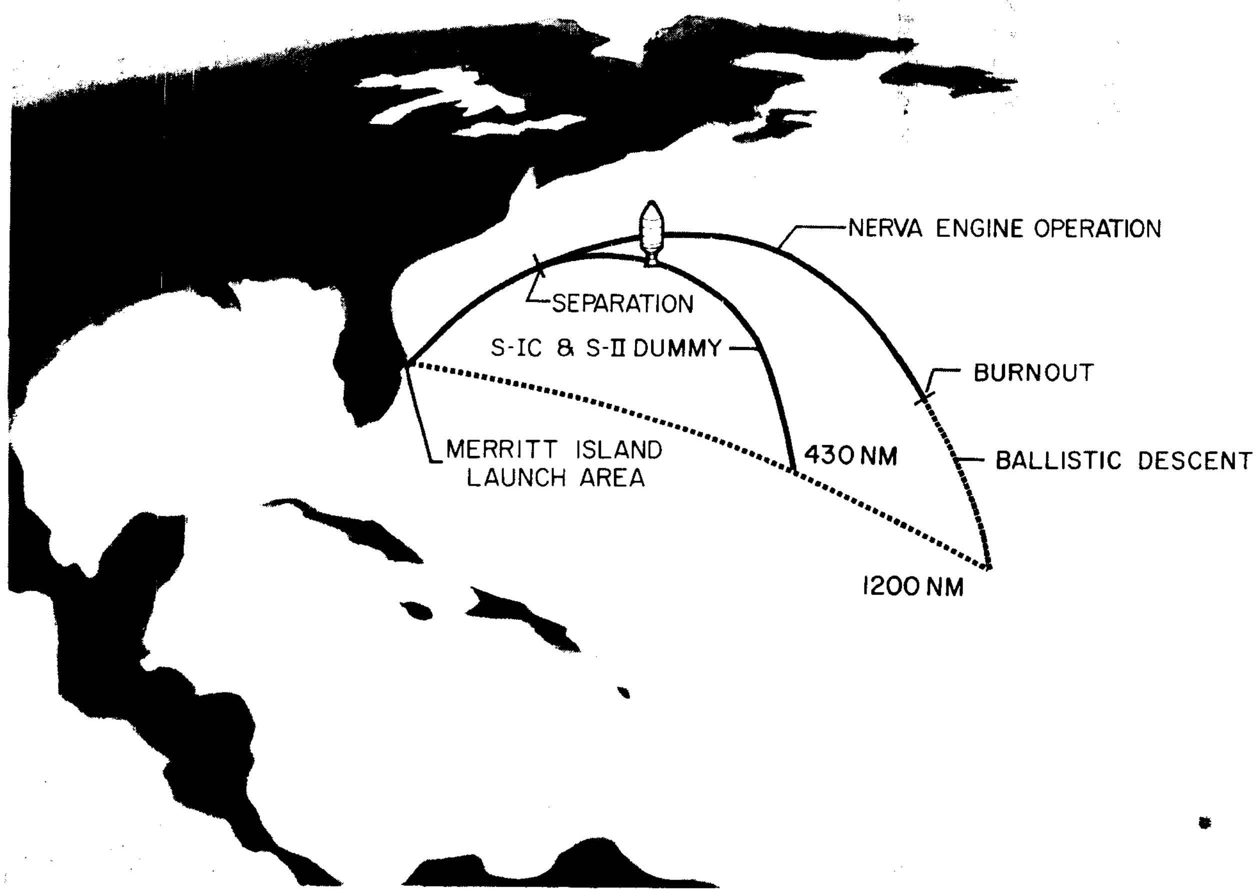

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Fig. 2-2 RIFT Two-Stage Lob Trajectory

3.2. NUCLEAR SPACE PROGRAMS DETAILED RESPONSIBILITIES

3.2.1. CUSTODY AND SECURITY

The NSP Quality Assurance division will be responsible for receiving the S-N stage, components, and materials and for maintaining their custody and security from delivery at the NSP receiving dock until transfer to NSP Stage Test for use in stage assembly. Nuclear materials are excepted from this responsibility; the NSP base manager personally will inspect and receive such materials into custody, subject to inspection by the Quality Assurance organization. NSP Stage Test will be responsible for custody and security of stage components and materials during assembly into the completed stage and for the stage as a whole until it is accepted and delivered to LOC at the agreed-upon perimeter. NSP Quality Assurance will be responsible for ensuring that only accepted and certified components and materials are issued to Stage Test for use in stage assembly.

3.2.2. RECEIVING INSPECTION

Nsp Quality Assurance will inspect and certify all materials, components, and stage and engine assemblies, including those furnished as GFE in accordance with procedures agreed to by NASA Quality Assurance. Accepted materials will be kept thereafter in bonded storage and will be segregated from noninspected or rejected components and materials. NSP Quality Assurance, after Material Review Board action, will reject unaccepted materials or components of vended or NSP manufacture. Operations and procedures will be as approved by NASA Quality Assurance.

3.2.3. CHECKOUT EQUIPMENT

NSP Quality Assurance, under overall supervision of LOC/LVOD, will inspect, calibrate, and certify all checkout equipment used in S-N stage assembly and checkout at MILA at the following:

a. Upon delivery

b. Upon completion of installation

c. Upon completion of any modification

d. Preestablished periods

NSP Stage Test, under overall supervision of LOC/LVOD, will operate, maintain, modify, remove and reinstall as necessary all checkout equipment. NSP Stage Test will ensure that only certified checkout equipment is used in the checkout of the S-N stage or its subsystems or components.

3.2.4. COMPONENT ASSEMBLY

NSP Stage Test will assemble certified components into the completed S-N stage using approved assembly procedures and techniques. It will also perform uncompleted Engineering Order modifications on the NSP - fabricated stage and components. Modifications to the nuclear engine assembly will not be made by NSP Stage Test if such modifications are required after delivery to NSP, the engine assembly will be returned to Aerojet-General or Aerojet General Corporation personnel directed by NSP to perform the modification, which will be subject to reacceptance by NSP Quality Assurance. NSP Quality Assurance will observe, verify, and certify all assemblies performed by Stage Test as acceptable and in conformance with stage specifications.

3.2.5. SUBSYSTEM ASSEMBLY

NSP Stage Test will assemble stage components into S-N stage subsystems in accordance with Quality Assurance approved methods and procedures. Stage Test will verify the functional integrity of each subsystem subject to specified audit point checks by NSP Quality Assurance and/or NASA Quality Assurance. Only Quality Assurance certified components and materials will be used in subsystem assembly, and only certified and currently calibrated checkout equipment will be used in functional testing and measurement.

3.2.6. STAGE ASSEMBLY

NSP Stage Test will assemble the checked-out stage subsystems, including the engine subsystem, into the S-N stage, using Quality Assurance approved methods and procedures. Stage Test will perform system checkout tests subject to audit point check and final acceptance by NSP Quality Assurance and NASA Quality Assurance prior to delivery of the assembled S-N stage to LOC. NSP Quality Assurance will conduct a Condition of Assembly for Release and Transfer (CART) meeting to affect the official transfer to LOC.

3.2.7. INSTRUMENTATION

NSP Quality Assurance will verify the calibration of all instrumentation components of the S-N stage and its subsystems prior to final delivery to LOC. NSP Stage Test will verify the functional performance of instrumentation during the various stages of assembly and checkout and will adjust, modify, or replace defective instrumentation on the stage only as required. NSP Stage Test will install, only as authorized by Engineering Order, additional instrumentation on the stage exclusive of the engine assembly. Aerojet-General will be responsible for instrument adjustment, modification, or replacement within the engine subsystem.

3.2.8. VEHICLE ASSEMBLY

NSP Stage Test will assist LOC during assembly and checkout of the RIFT Vehicle. Any such work performed will be accepted by LOC Quality Assurance.

3.2.9. ARMING TOWER

NSP Stage Test will install the S-N stage ordnance from the arming tower in accordance with the LOC procedures and methods. Components so installed will have been previously checked out and accepted by NSP Quality Assurance and/or NASA Quality Assurance. Installation will be inspected and accepted by LOC Quality Assurance.

3.2.10 LAUNCH PAD

NSP Stage Test will assist in final checkout and launch of RIFT vehicles as requested and directed by LOC, but only in those functions which pertain to the S-N stage and engine. Aerojet-General similarly will participate in final checkout and launch activities as requested and directed by LMSC/MSFC/LOC.

3.3. AEROJET-GENERAL CORPORATION

Aerojet-General will be responsible for the following:

a. On-schedule delivery to NSP of an instrumented engine assembly (GFE) completely ready for stage installation

b. Demonstration, to the satisfaction of NSP Quality Assurance, of the conformance of the engine assembly to applicable specifications

c. Provision of written acceptance by NASA Quality Assurance, on behalf of the Government, of the engine assembly

d. Accomplishment of all applicable engine modifications prior to delivery to NSP

e. Participation, as required and directed by NSP in stage-engine mating, engine checkout, and integrated stage and system checkouts up to final readiness for launch.

f. Supervision and direction, as the nuclear engine contractor, of the operations of Westinghouse with respect to delivery and acceptance of the engine nuclear subsystem and its installation into the engine

g. Provision for Aerojet-General's own receiving inspection of the engine, engine components, and engine instrumentation and calibration

h. Implementataon of NSP/LOC safety regulations while the engine and nuclear subsystem are in the custody of Aerojet-General

Aerojet-General also will be responsible to the AEC for the security and accountability of nuclear materials in Aerojet-General's custody until relieved of custody in writing.

Section 4
STAGE CONFIGURATION

4.1 INTRODUCTION

The Saturn VN Launch Vehicle (RIFT) will consist of three stages, an instrument unit and nose fairing, as illustrated in Fig. 2-1. The first stage will be powered by five F-1 engines using liquid oxygen and RP-1 propellants. The second stage will be a dummy SII. The third stage will be powered by the NERVA engine using liquid hydrogen propellant. Details of the third stage (S-N stage) are shown in Fig. 4-1.

Guidance and control of the RIFT vehicle are accomplished by equipment located in the instrument unit (IU). The IU will be a three foot slice physically located between the S-N stage and the nose fairing. Vehicle tracking equipment and associated instrumentation and power equipment will also be located in the IU. The nose fairing is conical with a spherical nose cap. Equipment or ballast within the nose fairing has not been defined yet.

A systems breakdown of the RIFT vehicle and S-N stage is shown in Fig. 4-2. Detailed descriptions of each system are given in the conceptual design documents. Only a general description of each system is given in the document. Following paragraphs give descriptions of the below systems:

NERVA system
Propulsion system
Structures system
Electrical system
Telecommunication system
Flight Termination & Separation system
Flight Control system

4.2 NERVA SYSTEM

The NERVA system as described in AGC 10095-NERVA Model Specification is a liquid-propellant turbopump-fed hot-bleed nuclear rocket engine. Liquid hydrogen is utilized as the propellant and is supplied to the reactor and nozzle assembly from a single-inlet, single-discharge centrifugal pump utilizing a mixed flow impellar with an integral inducer. The pump is directly coupled to a three-stage, axial flow impulse turbine. The turbine drive is gaseous hydrogen bled from the engine thrust-chamber assembly through a hot gas port located in the convergent section of the nozzzle. The hot-bleed gas is mixed with coolant gaseous-hydrogen flow from the reactor dome (plenum) to reduce the turbine drive gas temperature to the desired operating level.

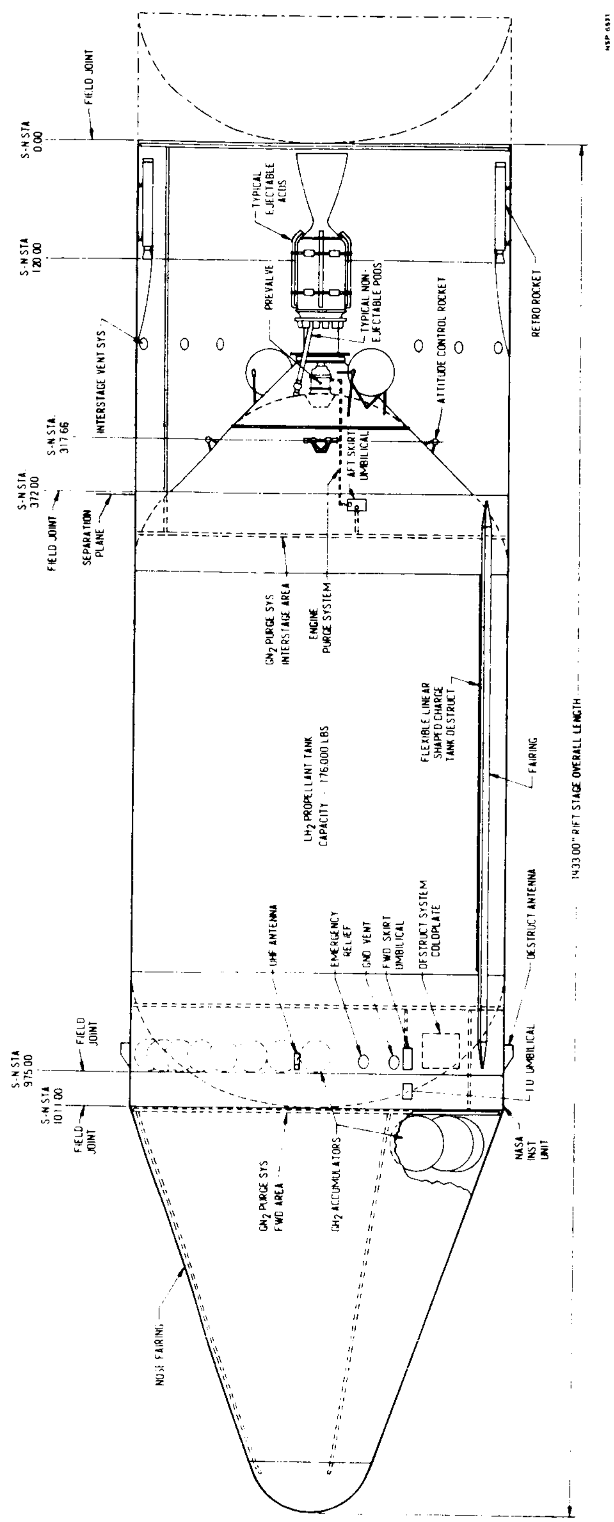


Fig. 4-1 S-N Stage Inboard Profile

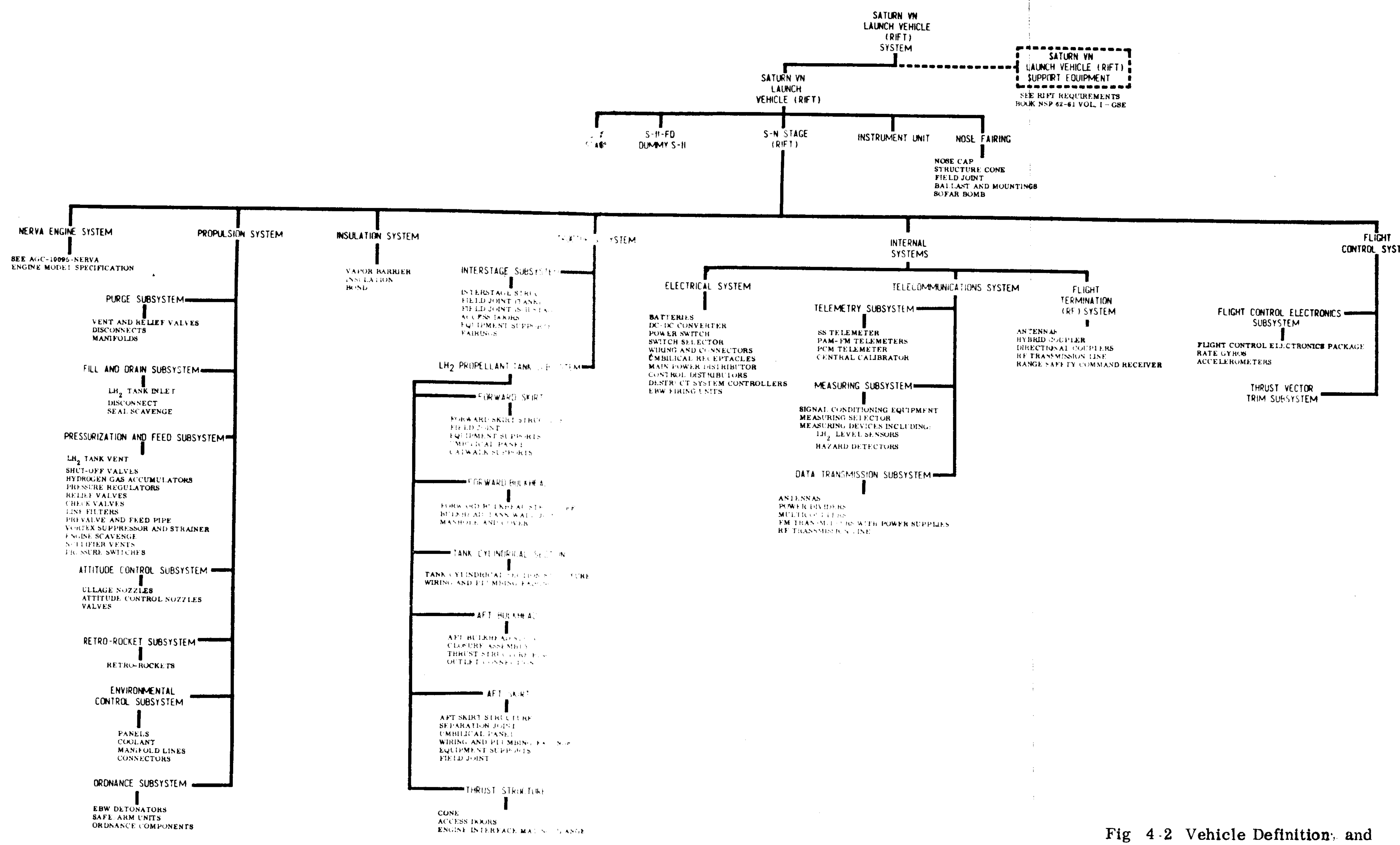


Fig 4-2 Vehicle Definition and Systems Breakdown

4.3. PROPULSION SYSTEM

As shown in Fig. [redacted] 4-2 , the Propulsion System is broken down into the following subsystems.

Purge
Fill and Drain
Pressurization and Feed
Altitude Control and Ullage Rocket
Retro-Rocket
Equipment Environmental Control

4.3.1.

The propellant tanks must be purged prior to initiation of propellant loading. The objective is to reduce to an acceptable level the content of all gases in the tank which would condense and solidify at LH_2 temperatures.
Since the initial purging in VAB will utilize gaseous helium, it will also be used in the NAB. Gaseous helium will be introduced into the stage during the initial NAB purge and retained for functional checkout and leak detection as a substitute for gaseous hydrogen. The S-N stage will be transported to VAB with a small positive pressure of gaseous helium.

4.3.2.

Propellant loading will be initiated with a chill-down phase at a low flow rate. During this phase the heat content of materials exposed to liquid hydrogen vaporizes the propellant as it enters the tank. Continuous venting of gaseous hydrogen will be necessary throughout chill-down. Fast fill at approximately 10,000 gpm will be initiated upon completion of chill down. This Fast Fill rate will be maintained until 98 percent of prelaunch loading requirements have been accomplished. A lesser fill rate of 500 gpm will then be utilized to fill to the 100 percent prelaunch requirement and for continuous replenishment to compensate for boiloff.

Draining of the tank because of a pre-launch emergency or a rescheduled launch time will be accomplished by forcing propellant out through the fill line by the tank pressurization subsystem. The length of time required to drain the tank is anticipated to be not greater than 150 percent of fill time. Residual propellant is vaporized by lowering the tank pressure.

4.3.3.

The pressurization system is shown in Fig. 4-3, [redacted] components consist of a three position ball valve, filters, a propellant tank pressure regulator, check valves, relief valves, a vent pressure regulator, a vent system shut-off valve, a remotely actuated ground disconnect, and two connectors at the NERVA/RIFT interface for the high and low pressure gas. The three position ball valve allows the storage bottles to be filled through the ground disconnect and the propellant tank to be pressurized from the ground. In addition it connects the engine plemum gas to the storage bottles and propellant tank. Except for a small amount of scavenge gas, the propellant tank regulator controls the flow of all gas entering the propellant tank in order to achieve and maintain the desired pressures throughout stage operation.

Liquid hydrogen supplied from the propellant tank flows through a strainer and then through anti-vortex baffles in the tank bottom where the tank merges with a propellant duct of approximately 18 in. diameter. In this section of the duct, a prevalve is located between the tank bottom and the stage-engine interface. The prevalve is a pneumatically operated diaphragm one-shot valve for flight stage. Prevalves on the captive stages will have the capa[redacted]bility to close after the initial rupturing of the disk.

4.3.4.

A cold gas attitude control system will be utilized during all phases of operation for pitch, yaw and roll control. This system is defined as that portion of Fig. 4-3 [redacted] beginning at the attitude control system shutoff valve and extending through the attitude control nozzles. There are two nozzle clusters, each containing three nozzles each nozzle contain[redacted] on-off control valve upstream of the converging portion of the nozzle.

Details of the attitude control subsystem are given in "RIFT Flight Dynamics and Control Analysis and Design Status Report", NSP-63-56, LMSC A 303895, 1 July 1963.

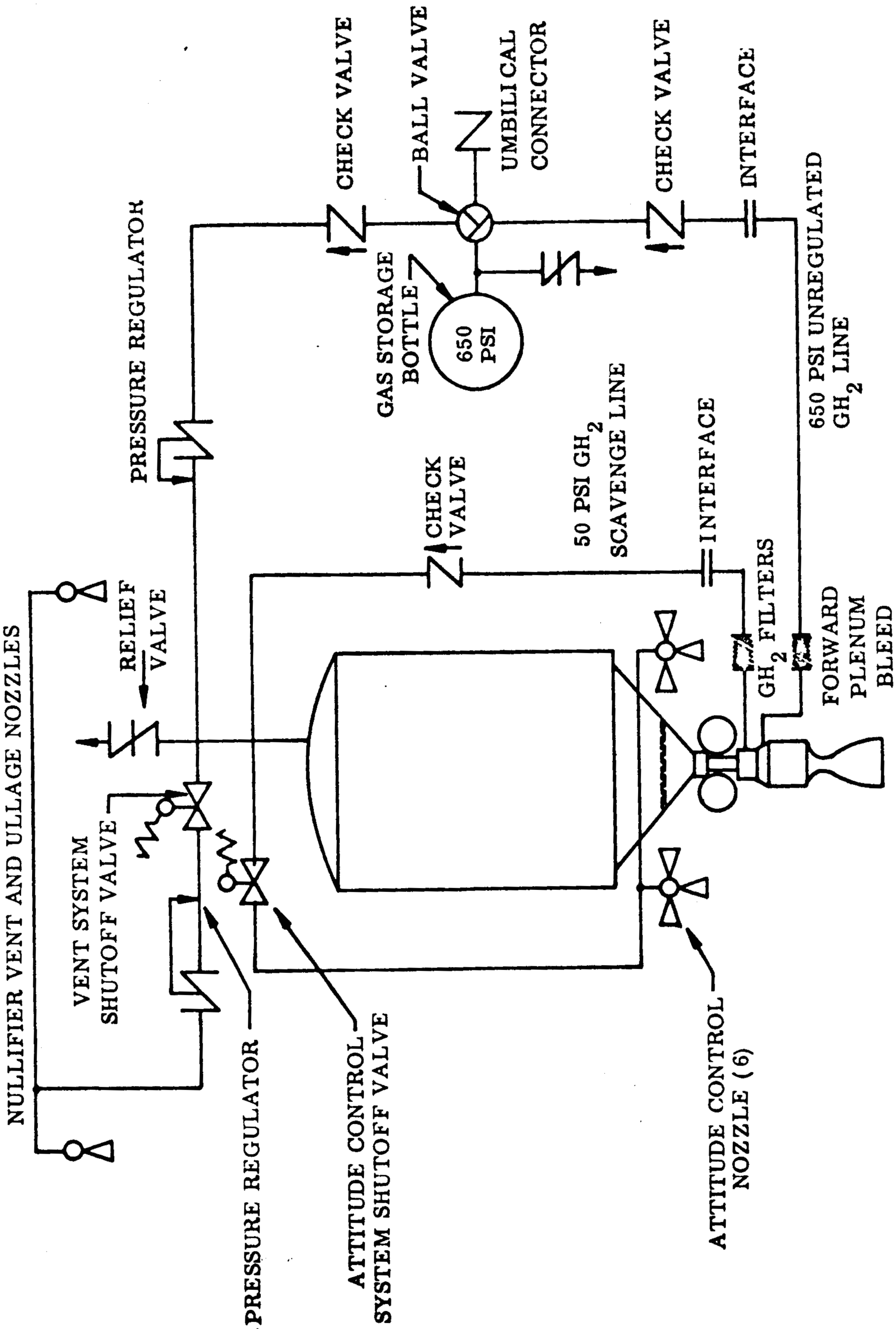


Fig. 4-3 Cold Gas Pressurization and Attitude Control System

4.3.5

Separation of the stage from the boost vehicle is accomplished by means of 12 solid propellant retrorockets. Eight of them are located on the F-1 engine fairings. The other four are located on the S-N stage interface. Ignition is accomplished by linear shaped charge actuated by an exploding bridge wire system.

4.3.6

Equipment environmental control will be accomplished by use of Instrument Unit environmental control system. Figure 4-4 shows a block diagram of the environment control subsystem. Dashed lines represent the modification that will be incorporated to cool S-N stage electronics. Temperature control is achieved by controlling the rate of water boiloff from the flight boiler during flight and by controlling the temperature of incoming fluid from GSE during ground checkout.

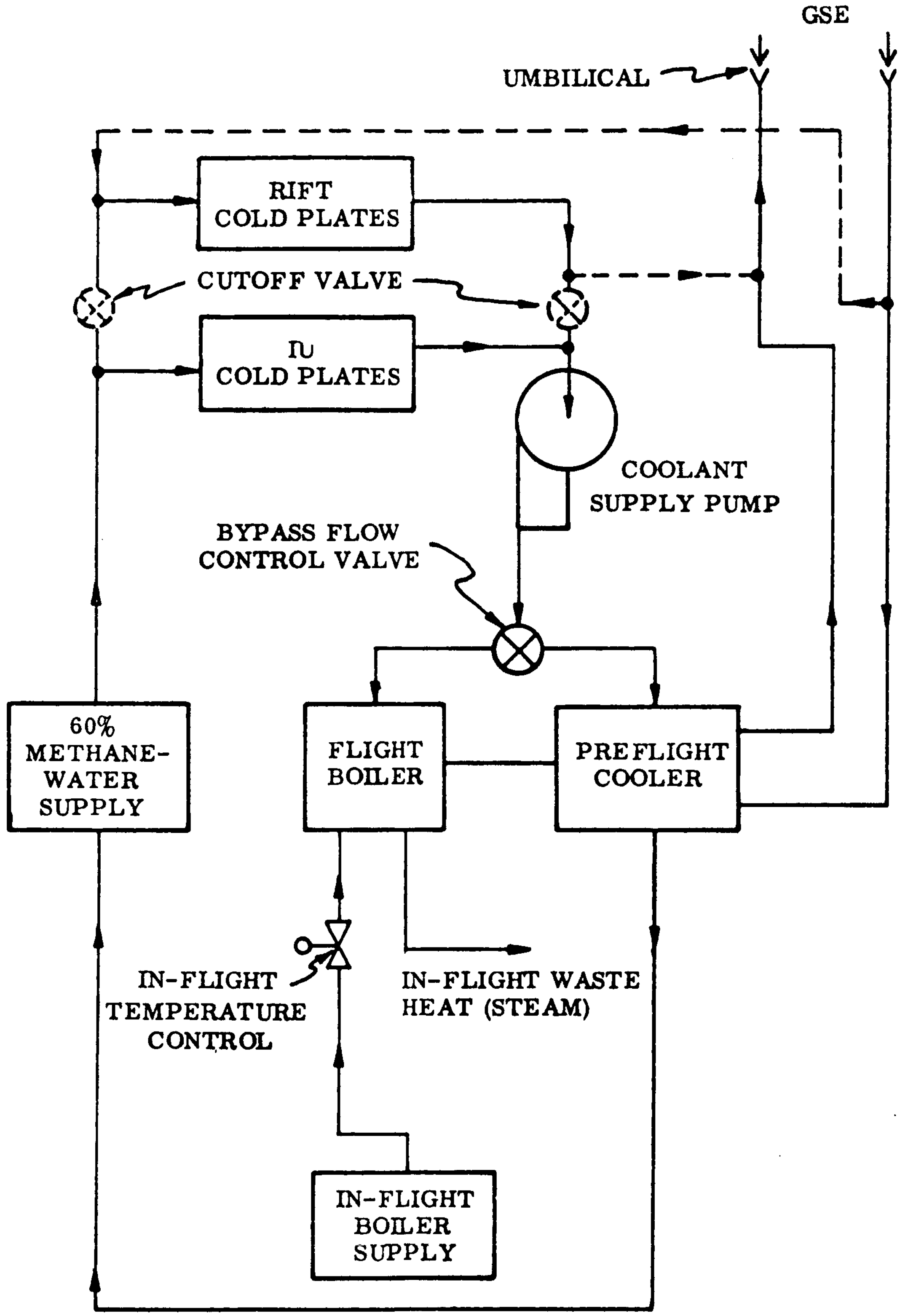
4.4 STRUCTURES SYSTEM

The LH_2 tank subsystem of the structures system is composed of the following components:

Forward Skirt. The forward skirt structure is constructed of four, aluminum, integrally stiffened wrap-around panels welded together. To this skirt are attached environmental control plates on which the electronics located in the forward section of the S-N stage are mounted. This skirt also contains the electrical umbilical panel for the S-N stage and the GH_2 vent disconnect which is separate from the umbilical panel.

Tank Forward Bulkhead. The tank forward bulkhead forms the tank top. It consists of aluminum milled- and formed- segments welded together and terminating at a forward ring within which is attached a 30-inch-diameter access cover.

Tank Cylindrical Section. This section is comprised of smaller cylindrical sections welded together. Each of the smaller cylindrical sections is made from four, aluminum, integrally stiffened wrap-around panels welded together.



NSP 6377

Fig. 4-4 Electronic Cooling System

Aft Bulkhead. The aft bulkhead structure is formed of three major sections: (1) an ellipsoidal forward section, (2) a truncated cone mid section, and (3) an ellipsoidal aft section which contains the tank outlet fittings. These major sections are composed of smaller skins, milled and welded together.

Aft Skirt. This skirt is constructed of four, aluminum, integrally stiffened wrap-around panels welded together. Just forward of the skirt aft field joint is the separation joint for explosively separating the S-N stage from the S-IC/dummy S-II portion of the vehicle. This skirt contains an umbilical panel and a liquid-hydrogen fill-and-drain disconnect separate from the umbilical.

Thrust Structure. The thrust structure is an aluminum truncated cone. It transmits the thrust of the NERVA engine from the engine/stage interface mating flange to the aft bulkhead. This structure contains and supports the actuators and mechanism associated with the thrust vector trim subsystem.

Insulation. The LH_2 tank has an internal insulation of hydrogen-gas-filled foam. The surface of this insulation is covered with a vapor barrier which also serves to reinforce the insulation.

The interstage subsystem of the structures system is formed of aluminum corrugated-panels and rings. It contains an access door for entry into the interstage area and houses the forward retrorockets used for separation.

4.5 ELECTRICAL SYSTEM

The S-N stage electrical system consists of primary batteries, power converters, switches, power distribution and control units, wiring and connectors, and the umbilical receptacles. Electrical systems isolation from other Saturn stages is maintained even during transfer of signal or commands to or from another stage.

4.5 cont'd

Power distribution is shown in Fig. 4-5. The internal power for the S-N stage will be supplied by a three-bus battery system. One bus will be used for stage equipment including one of the two separate command destruct systems. A second bus will be used for engine equipment and the second command destruct system. Both of these buses will supply a nominal 28 vdc. A third bus will provide a nominal 56 vdc for use with large electro-mechanical devices. Except for the common connection of each bus to the stage single point ground, each bus will be electrically isolated from the other buses.

A single manually activated battery will be used for each bus. The number of cells per battery can be varied between 18 - 21 cells to obtain the desired output voltage. Each battery will be capable of a no-load stand time of 72 hours at 122°F after activation.

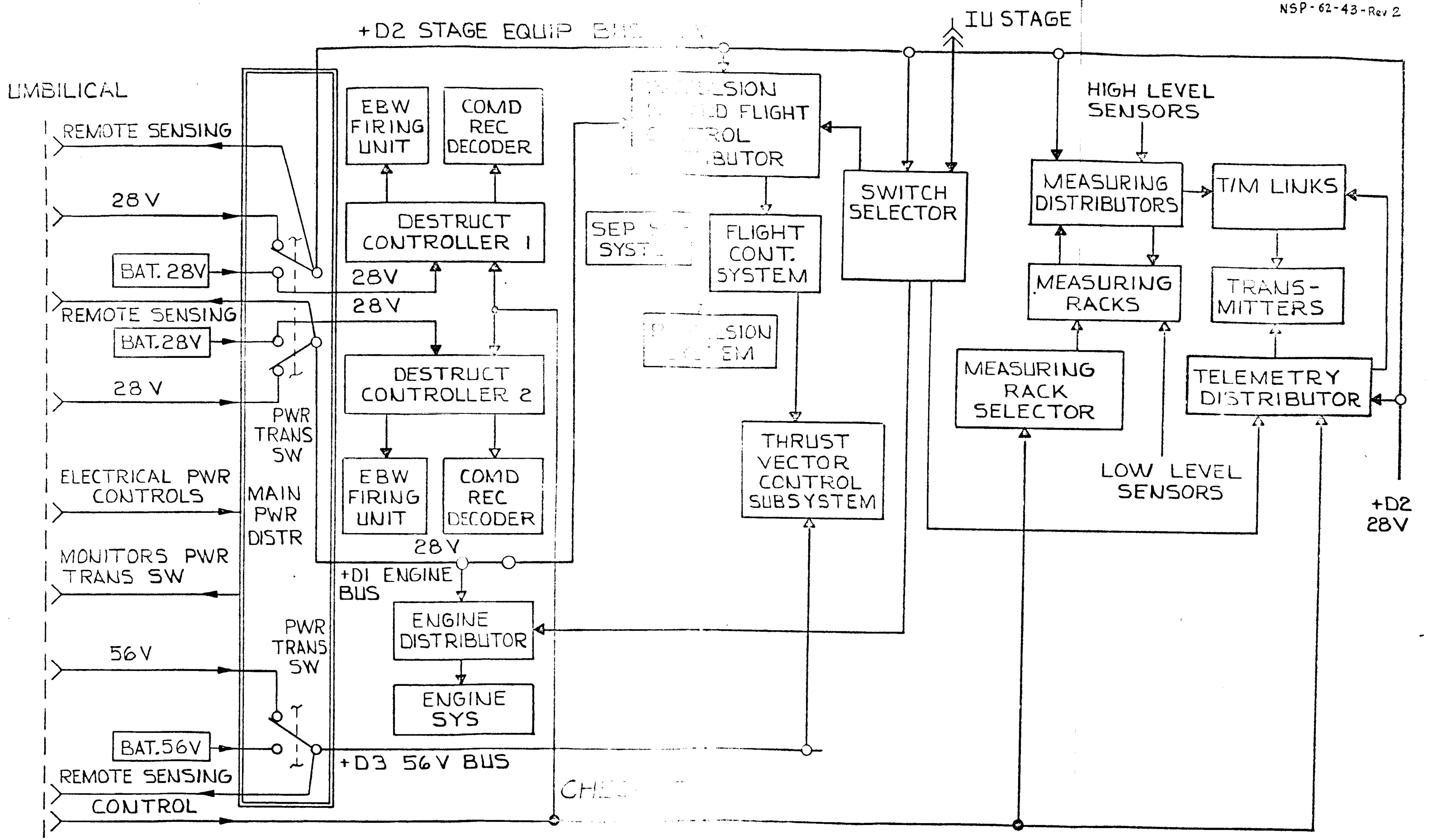
A power switch provides the capability, upon receipt of a transfer signal, to transfer the source of power from external to internal and vice versa.

Control distributors upon command via umbilicals will switch power.

Details of the Electrical System as well as the Telecommunications System, and Flight Termination and Separation System are given in RIFT DSD 212 "Formal Design Review Report, Internal Systems".

4.6 TELECOMMUNICATIONS SYSTEM

The basic objective of the telecommunications systems of the S-N stage is to provide performance data during test flight. These data are to be transmitted to ground monitoring stations and are to be used for post-flight performance evaluation, failure analysis, and safety monitoring. The system is composed of measuring, telemetry, and data transmission equipment. The telemetry system distribution including "on/off" command capability is shown in Fig. 4-6.



ELECTRICAL SYSTEM POW ... IBUTION AND CONTROL

FIG.

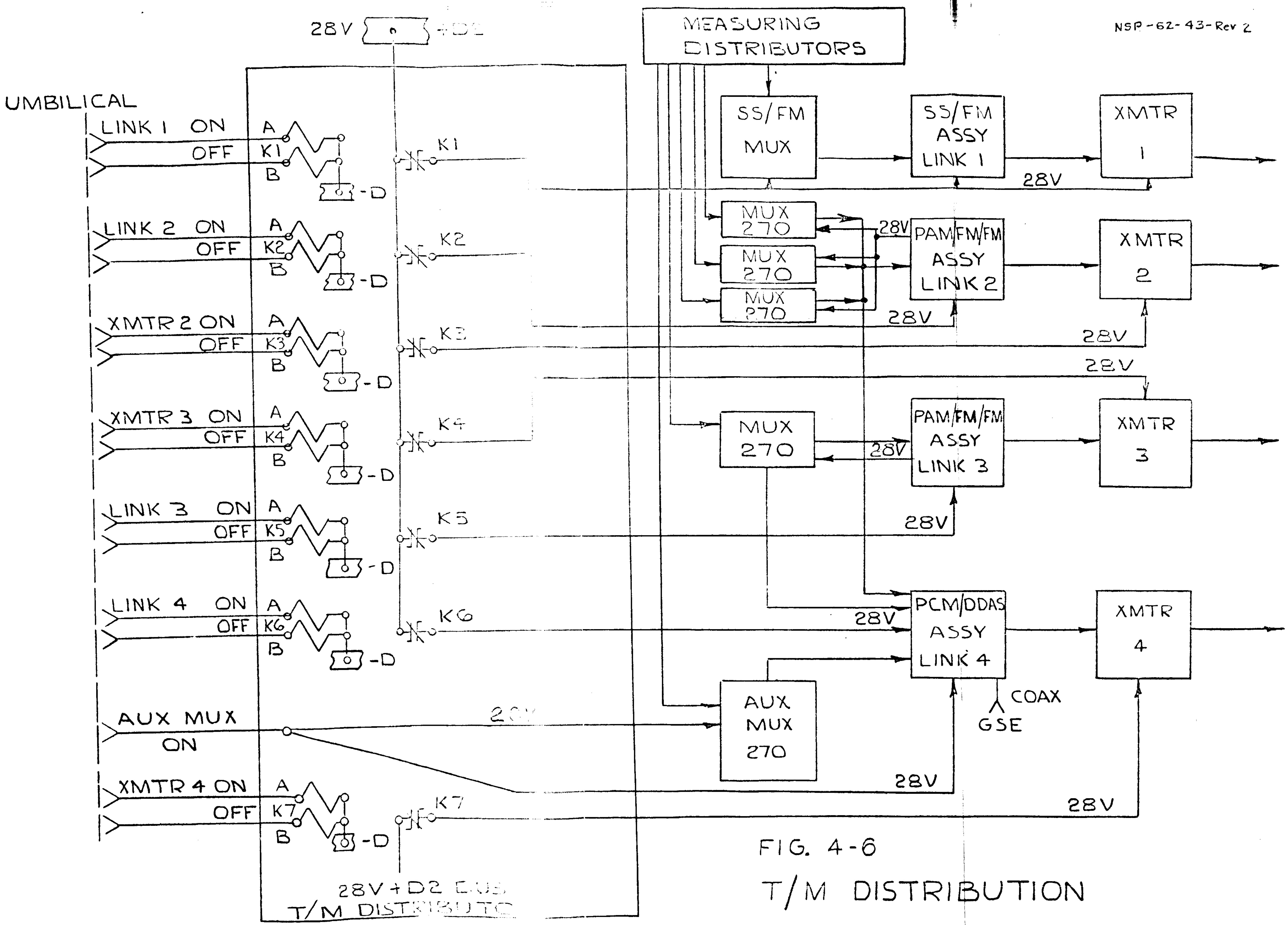


FIG. 4-6
T/M DISTRIBUTION

4.6 cont'd

Measuring Equipment. The measuring equipment consists of measuring instruments, signal conditioners, and calibration devices. This equipment will monitor parameters which include strain, temperature, voltage, current, mechanical position, vibration, noise, switch closures, radiation, pressure, etc. The Saturn VN launch vehicle is expected to monitor and transmit about 1,800 in-flight data points to ground receiving stations; the S-N stage itself will monitor about 600 points. Fig 4-7 shows types, numbers and locations of monitoring points on the RIFT stage.

Telemetry Equipment. Three types of frequency modulation (FM) telemetry systems are to be used by the Saturn VN launch vehicle. They are single sideband (SS/FM), pulse code modulation (PCM/FM), and double-frequency modulation (FM/FM) systems utilizing high-speed pulse amplitude modulation (PAM) of one of the 14 subcarriers (PAM/FM/FM).

Single sideband/FM systems transmit high-frequency data (e.g., vibration). The PCM/FM system, which is used primarily for automatic checkout, provides high-accuracy in-flight data and serves as a redundant system for most flight data. PAM/FM/FM systems transmit the majority of the flight data.

The S-N stage contains the following telemeters:

1---SS/FM
1---PCM/FM
3---PAM/FM

Data Transmission Equipment. This equipment consists of the antennas, transmission line, switches, couplers, and transmitters necessary to transmit the telemetry multiplexers output to the ground receiving stations.

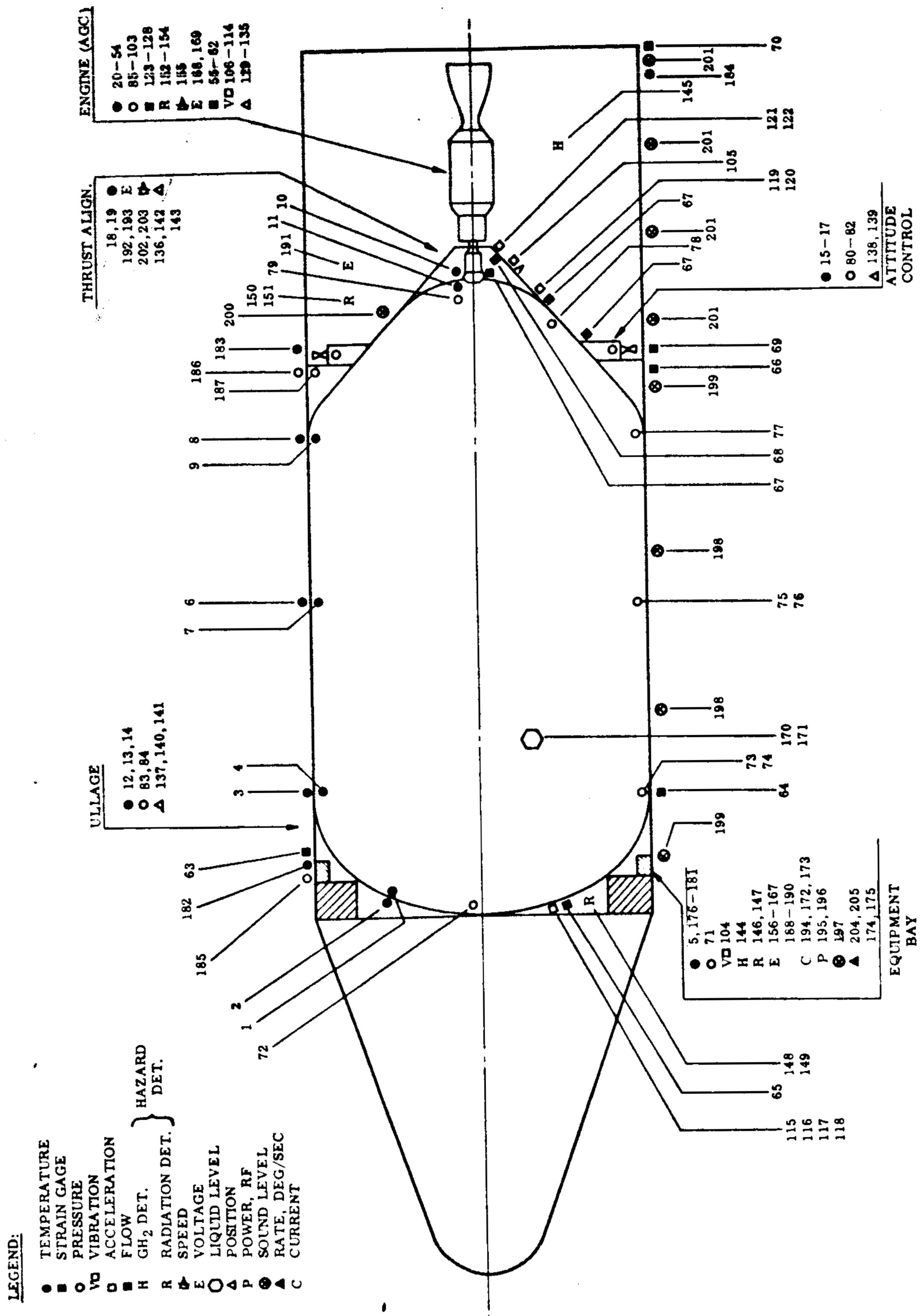


Fig. 4-7 Measuring Subsystem

4.7 FLIGHT TERMINATION AND SEPARATION SYSTEM

The Flight Termination subsystem provides the means to terminate flight in the event of deviation from the planned vehicle or stage performance. The S-N stage will be capable of flight termination upon receipt of a coded RF command from the Range Safety Transmitter via either of two independent redundant command links.

The subsystem consists of the following:

Antennas
Hybrid couplers
RF transmission line
Range Safety command receivers
Destruct system controllers
EBW firing units
Safe/arm units
Ordnance components

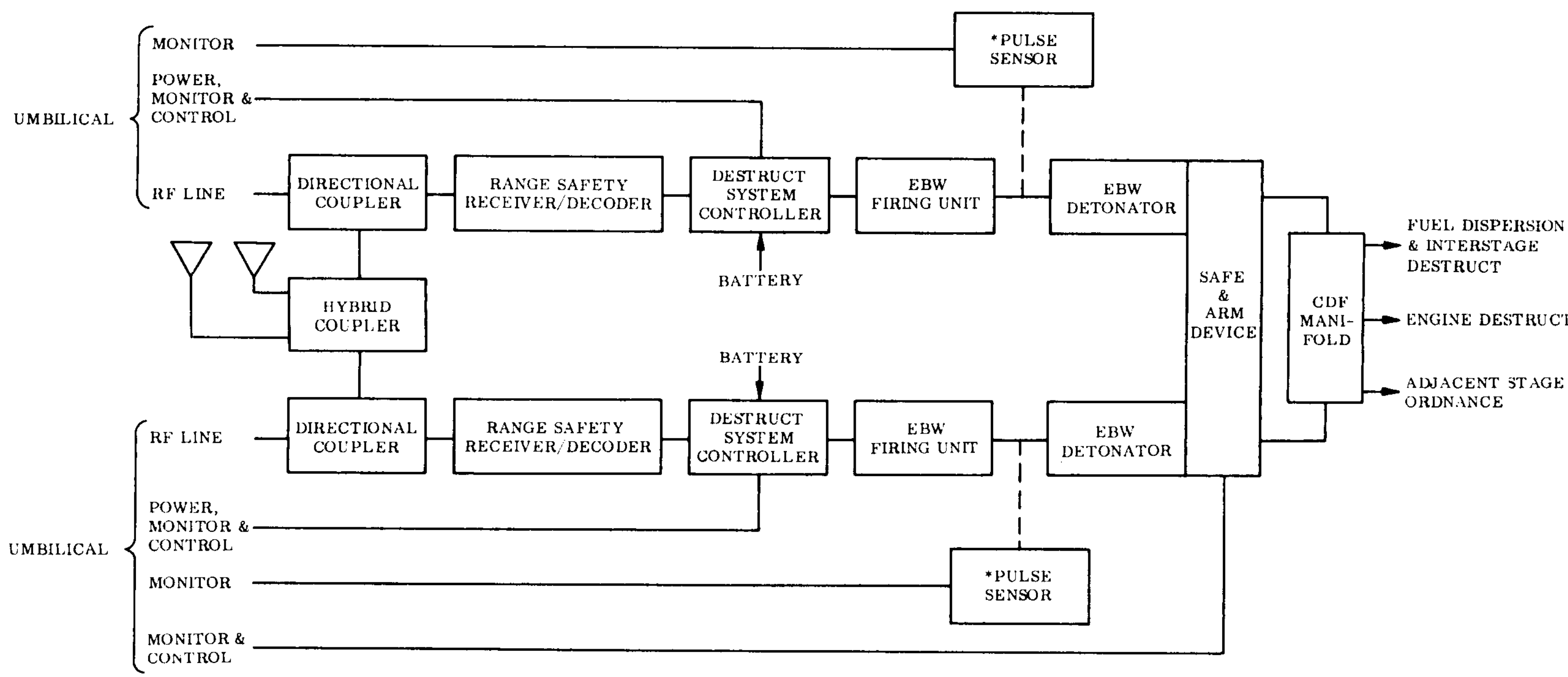
Inter-relationship of the above is shown in Fig. 4-8.

The separation subsystem provides a means of releasing the S-N stage from the interstage and the lower adjacent stage by means of a circumferential cutting charge. It also initiates retrorocket operation. The subsystem consists of EBW firing units and ordanance components.

4.8 FLIGHT CONTROL SYSTEM

The Flight Control system requirements of a typical RIFT trajectory for the S-N stage include:

- Roll control by reaction jet system at all times.
- Pitch/yaw separation recovery during 40 - 50 sec. of initial thrust buildup and restart phases by combined thrust vector trim and reaction jet system.



Note: Minimum requirements are shown. Antenna system and selected ordnance components may be redundant.

*Pulse Sensors are removed for flight.

Fig. 4-8 Flight Termination Subsystem

4.8 Contd.

Attitude control commands are generated by the guidance and control computer in the IU and supplied to the S-N stage via a central trunk line.

A reaction jet system will provide three-axes control during engine cooldown, attitude maneuvers, and attitude stabilization associated with the coast phase. The reaction jet system provides thrust by expending gaseous hydrogen from two clusters of three jets each located 180 degrees apart on the circumference of the stage. Selection of jets determines direction of thrust.

A thrust vector trim system provides pitch/yaw control during the steady-state powered phase. This is accomplished by engine movement to change direction of thrust vector.

Section 5

FACILITIES

5.1 FACILITY DESCRIPTION

The RIFT Checkout and Launch Program will require use of facilities of AMR Launch Complex 39. These facilities will include a bay of the Vertical Assembly Building, the Arming Tower, a launcher/transporter, a launch pad, and the Launch Control Center, as well as the engineering shops, the Liquid Hydrogen Facility, and other support facilities. In addition, technical support functions will be provided by the Nuclear Assembly Building. A preliminary concept of Launch Complex 39 is illustrated in Fig. 5-1.

The Nuclear Assembly Building (NAB) will contain four major areas; a reactor assembly and a checkout room, an engine checkout and reactor/engine mating area, a shielded control room from which all engine/reactor nuclear calibration tests are performed, and two highbay areas where vertical engine/stage mating and checkout operations will occur. The highbays, in conjunction, with the control room,contain all the high pressure gas sources, GSE, and the automated computer complex for complete "flight-readiness" check-out of the stage/engine/reactor systems. An overhead crane will provide stage handling. In addition, the NAB will satisfy requirements for: (1) health physics and radiation activity, (2) radiation detection and warning system, (3) personnel change room, (4) decontamination area, (5) storage of decontaminated equipment, (6) instrumentation laboratory, (7) spare parts storage, (8) first aid and, (9) machine shop.

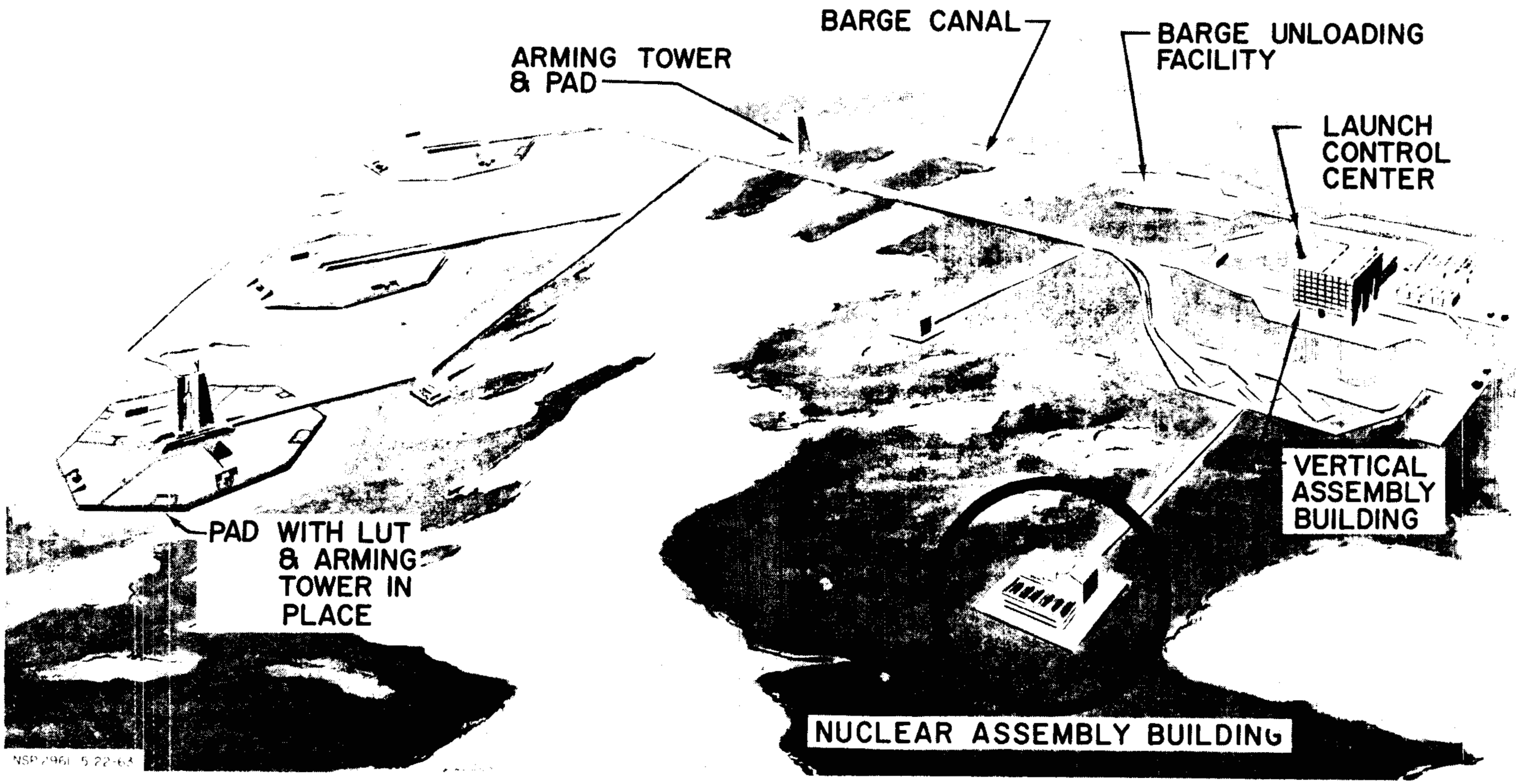


Fig. 5-1 Merritt Island Launch Area (Complex 39)

5.2 COMPLEX READINESS CERTIFICATION PRIOR TO STAGE TESTS

The RIFT portion of Complex 39 will be activated as required to support the RIFT Program schedule. Activation will progress from initial receipt and installation of individual items of equipment (facility, GSE, checkout, and launch equipment) through an operational readiness test and complex readiness certification. Activation will be accomplished in five phases in the following order.

1. Installation
2. Installation checkout
3. Subsystem tests
4. System integration tests
5. Operational readiness tests.

Activation will be conducted under the direction of NSP Stage Test personnel.

Acceptance tests for the ground support equipment will be conducted as an integral part of complex activation to assure that the GSE satisfies the design requirements. The tests will progress from tests of individual items through tests of subsystems. NSP Stage Test will accomplish the following in support of the GSE acceptance tests:

Establish criteria for equipment acceptance

Provide detailed acceptance test plans

Provide technical personnel to conduct and to witness the tests

Prepare test reports.

In line with Saturn V program, requirements for Facility Checkout Stages, the Dynamic Test Stage, S-N-D, will be utilized for verification of compatibility with the Facility. Electrical compatibility will be verified with simulators and Flight Stage, S-N-1.

5.2 cont'd

Following complex readiness certification and as a continuing requirement prior to each flight, NSP Stage Test will perform an operational readiness evaluation. The functions performed will be as follows:

1. Review the status and capability of all launch-base GSE to determine its operational readiness.

2. Review the flight plan and all test and operations procedures at the launch base to insure compatibility between equipment and systems test requirements.

3. Evaluate the information resulting from performance of the above reviews to determine the operational readiness of the overall system.

4. Evaluate the performance and status of equipment and stations after each flight for purposes of making recommendations to affected organizations.

Section 6

NAB OPERATIONS

6.1 GENERAL

This section covers NSP Operations at MILA prior to mating in the VAB. Except for transporting these operations are conducted in the NAB. The NAB operations are planned to satisfy applicable objectives under Nuclear Safety and RIFT Stage Development in the Introduction. Listed below in chronological sequence are the general operations in this section:

Off-load S-N stage less engine and interface
Off-load interstage and nose f
Transport to NAB
Perform receiving inspection
Accomplish engineering modifications
Checkout
Mate engine
Checkout
Transport to VAB

6.2 OFF-LOAD/TRANSPORT

Upon arrival at MILA, the S-N Stage less engine and interface secured to the overland transporter is off-loaded from the barge and transported to the entrance of the NAB. The protective cover is removed, slings are attached to the forward and aft handling ring, each sling is attached to a crane hook and the stage is lifted, pivoted to vertical and placed in the On-site Transporter. The On-site Transporter moves the stage to the Stage Mounting Stand in the NAB, places the stage in the stand and returns to the parking area. Figure 6-1 and Figure 6-2 show stage transporting and handling at MILA.

Along with the stage, the transporter holding the interstage with the nose fairing inside is off-loaded and transported to the receiving-inspection area in the NAB. The interstage/nose fairing transporting is shown in Figure 6-3 .

6.3 NAB OPERATION

RIFT STAGE HANDLING PLAN-MILA

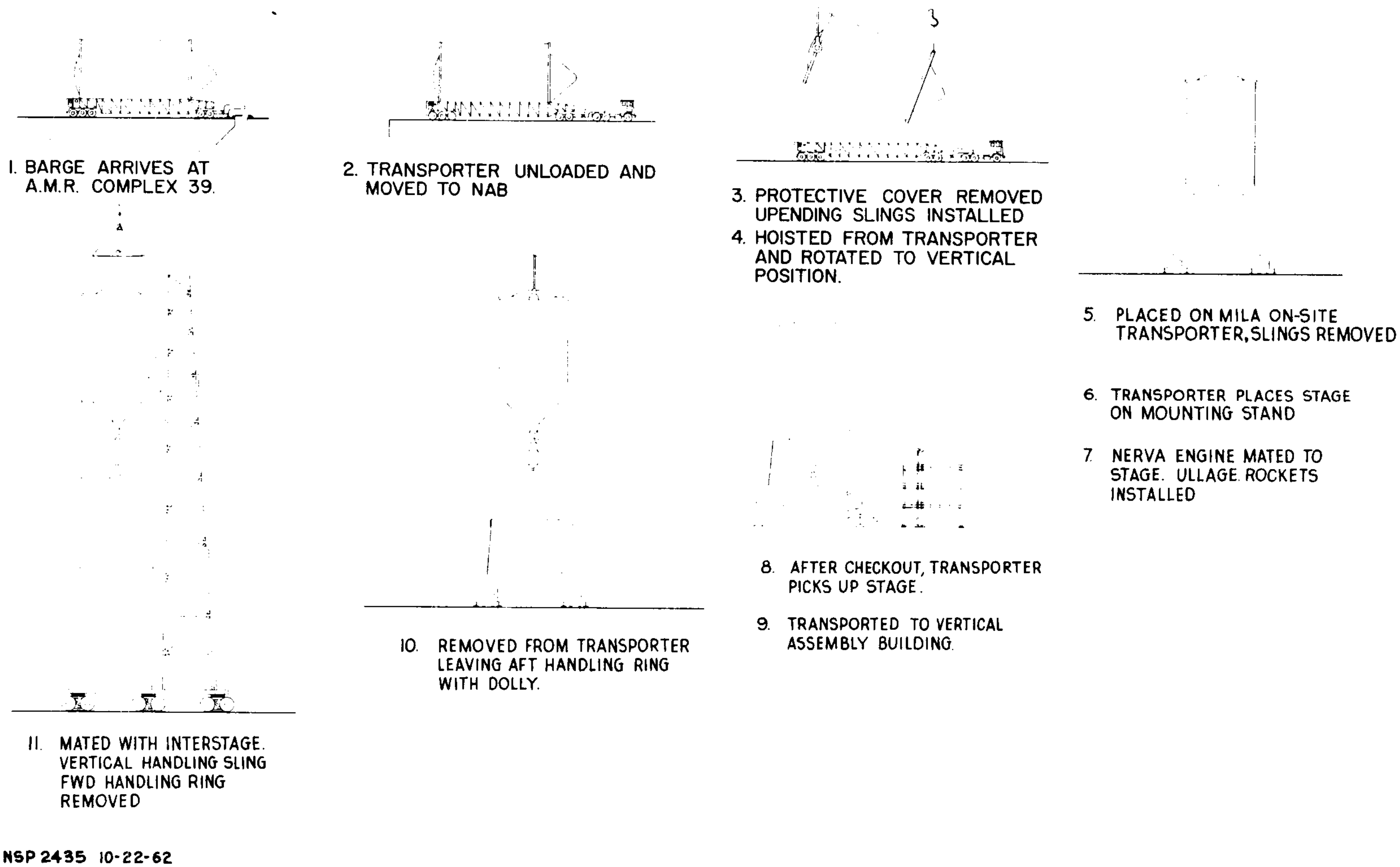


Fig. 6-1 RIFT Stage Handling Plan – MILA

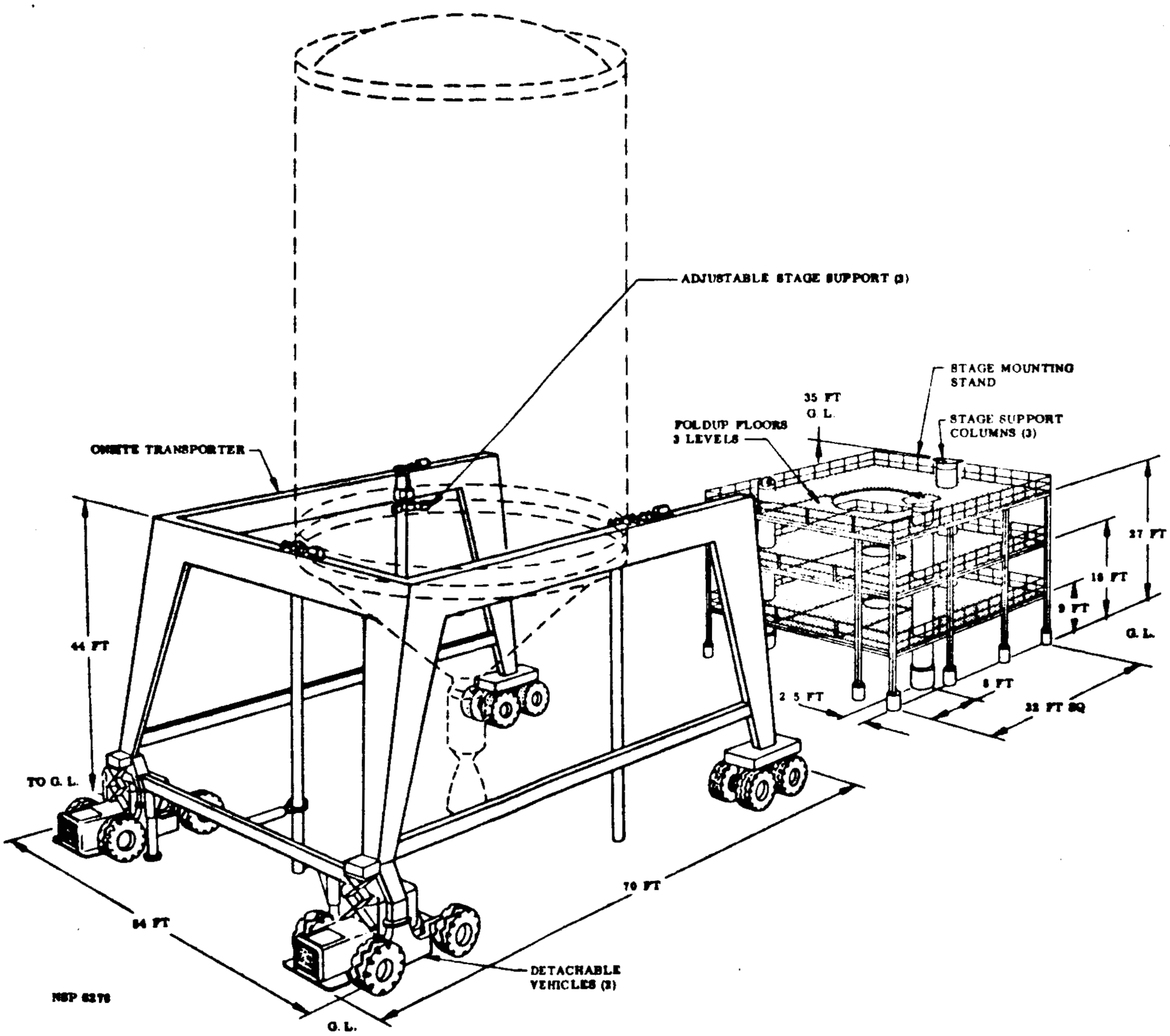


Fig. 6-2 Onsite Transporter and Stage Mounting Stand

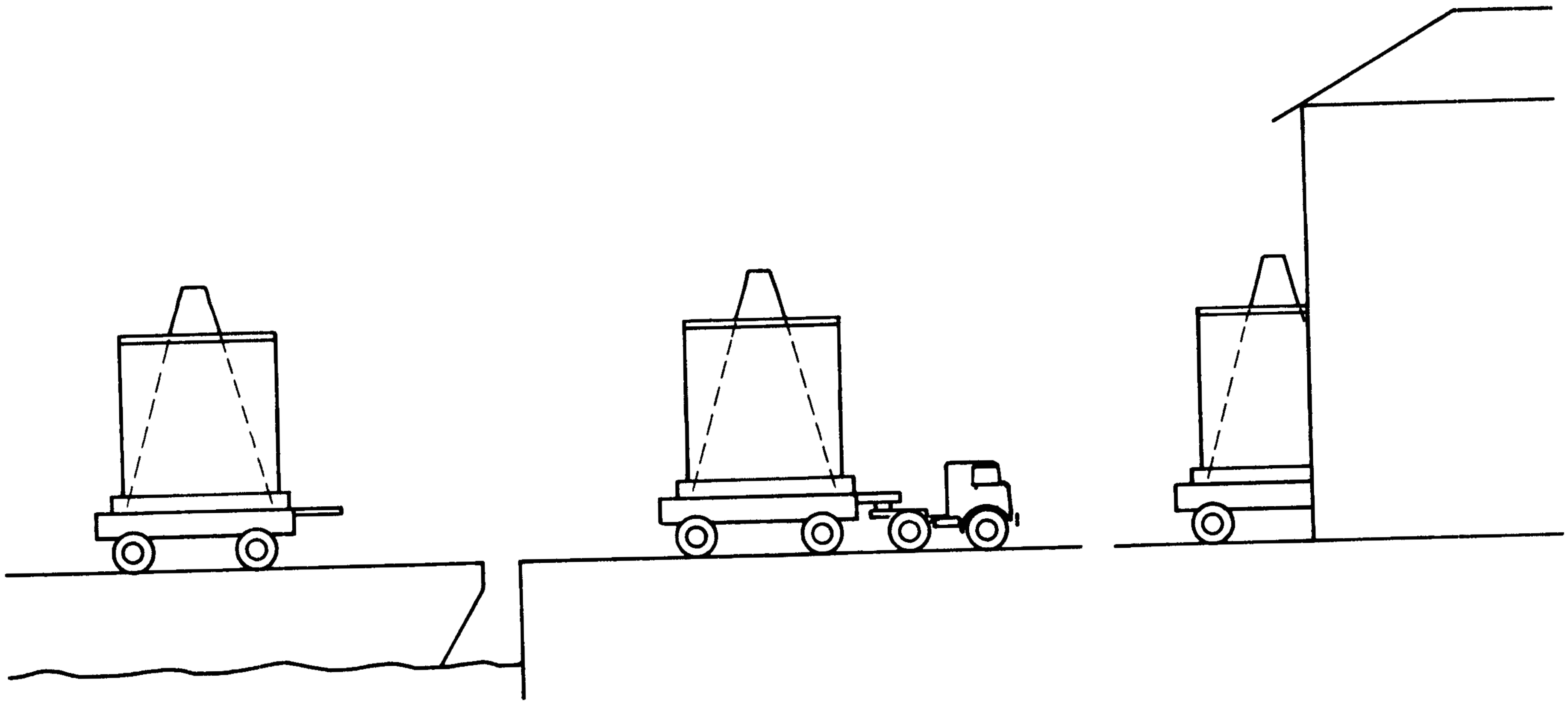


FIG. 6-3 TRANSPORTATION OF THE INTERSTAGE AND NOSE FAIRING

6.3.1 RECEIVING INSPECTION

A visual inspection of the S-N stage, nose fairing, interstage and all separately shipped components will be conducted by NSP Stage Test and NSP QA on arrival at NAB to locate externally damaged or loose equipment. NSP QA will inspect data records for the stage to confirm that delivery requirements have been satisfied. NSP Stage Test will analyze in-transit data recordings to uncover out of limit environments experienced during transit.

6.3.2 PREPARATION FOR CHECKOUT

Before starting checkout, mandatory engineering modifications (changes resulting from engineering design changes) will be accomplished, electrical GSE will be verified, and disassembled components will be checked and installed on the stage. Engineering modifications will be reviewed, classified and scheduled. Those of a mandatory status affecting stage checkout will be completed before starting checkout. At the same time all electrical GSE including tape comparators will be connected to GETS and verified to be functioning correctly. Upon completion of the tape comparator verification, the disassembled components will be checked out and installed on the stage.

Early in the modification and component assembly phase, the manhole in the tank dome will be removed and with proper scaffolding the tank insulation will be inspected. Any required rework will be accomplished.

6.3.3 CHECKOUT

At the completion of preparation, umbilicals will be made and electrical and pressure lines will be attached to the stage. Each test station becomes integrated with the stage to form a complete checkout system; however, an individual test station can operate independently with the stage in a trouble shooting application if desired. Checkout will be initially started with electrical continuity checks and will follow the sequence in Table 6.1. The end of preparation and start of checkout will not be a clean break. Checkout will begin with the first opportunity to start. For instance, continuity checks will be conducted along with the

Table 6.1

CHECKOUT SEQUENCE

1. Preparation for checkout
2. Continuity check
3. Bus voltage check
4. DDAS checkout
5. Purge and pressure
6. Leak check
7. Mechanical functional check
8. Telecommunications checkout
9. Attitude control checkout
10. Flight termination and separation checkout
11. NERVA checkout - stage side of interface
12. Engine mate and alignment
13. Interface and engine system checkout
14. Propulsion system checkout
15. RF compatibility test
16. Simulated plug-drop overall test
17. Simulated flight test

6.3.3 cont'd

installation of disassembled components. In addition, checkout will be conducted on a parallel basis as feasibility exists; however, checkout is discussed on the basis of a serial operation.

A comprehensive continuity check is a simple, convenient method of locating passive faults, some of which could cause equipment damage upon application of electrical power. The first step of checkout, therefore, is a continuity check. A bus voltage check, the second step in checkout, is an additional simple step in preventing damage and verifying satisfactory performance.

After safe application of electrical power, the DDAS system will be checked out. The DDAS is to be used as the primary monitoring system for stage checkout; therefore, early checkout and calibration is essential.

Mechanical checkout, which covers the operation of valves and actuators, will be started with a purge by gaseous helium. The tank and pressurization subsystem will be filled with gaseous helium and a complete leak check will be conducted. During pressurizing, items such as valves, check valves,regulators and filters will be monitored for correct operation. After pressurizing, the pressurization system will be functioned and pneumatic items such as valves and actuators will be operated.

Next the electronic systems will be checked out, starting with the Telecommunications system. PAM multiplexers and the PCM subsystem have previously been checked out with the DDAS checkout. At this time the SS/FM telemetry and FM/FM channels will be checked along with all transmitters and the rf portion (excluding the antennas) of the system. The outputs of telemetry ground stations will be monitored for correct overall Telecommunications System operation.

The sequence of other systems checout is irrelevant; however, for discussion the Attitude Control and Ullage Rocket Subsystem checkout will be next. Although the

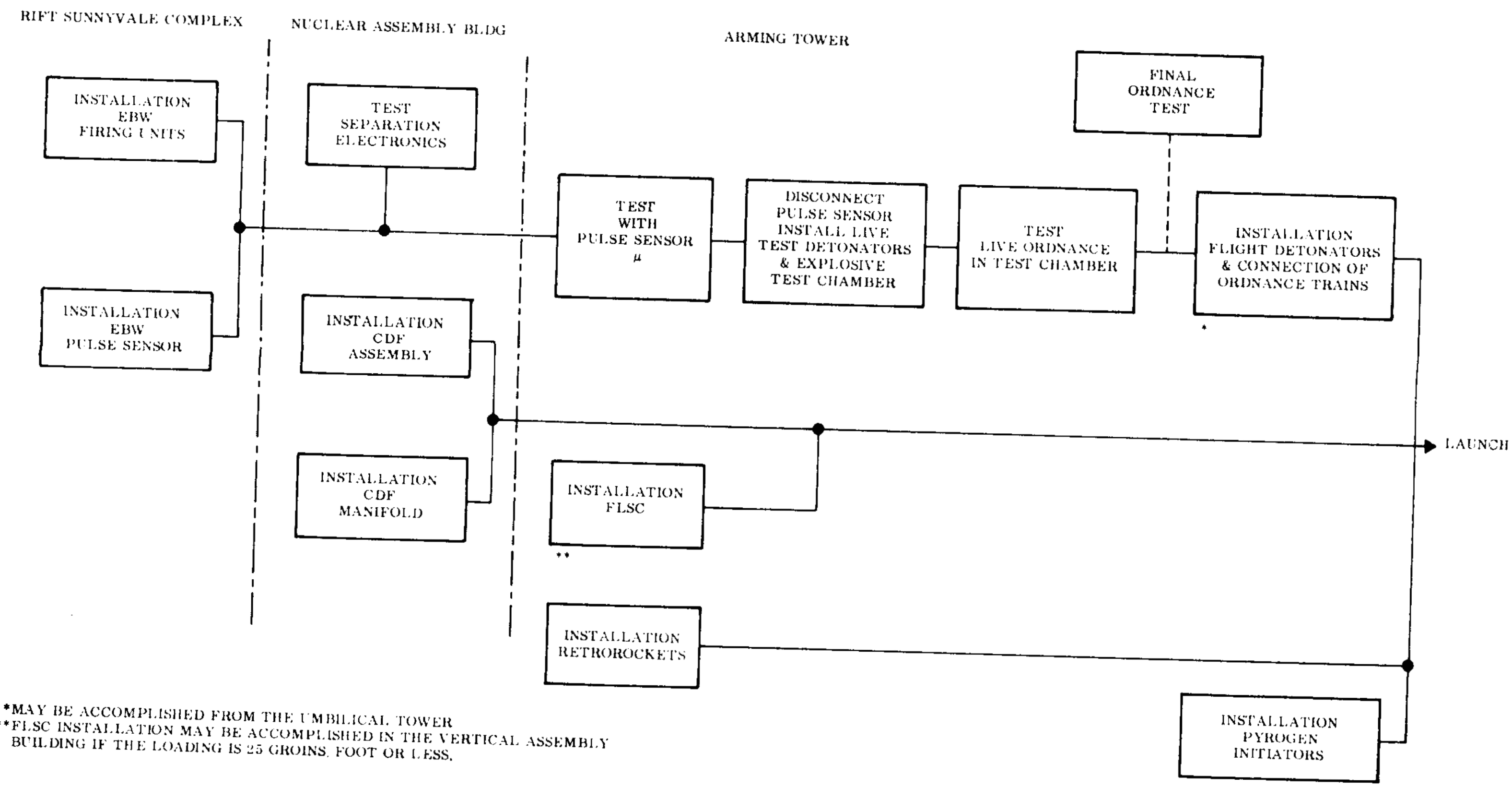
6.3.3 cont'd

valves for controlling the exhausting gas are not specified, they will probably be large solenoid valves that should not be operated dry. Electrical signals will be directed to the solenoids with the results monitored through DDAS.

Flight Termination and Separation System checkout will utilize the GFE test equipment and follow procedures already established for that equipment. Fig. 6-4 is a flow chart showing installation and test of ordnance components for the S-N stage.

Checkout of the stage portion of the NERVA System will utilize the engine simulator. This checkout is an electrical checkout composed of signals to and responses from the engine simulator. At this point of the checkout, the engine will be moved to the stage from the engine preparation area. A visual inspection of the engine will be made along with a check on the accompanying documentation. The engine preparation being in the same building as the stage preparation allows close monitoring of engine checkout by Stage Test engineers; therefore, the engine can be mated to the stage almost immediately upon movement into the stage preparation area.

Engine alignment to the stage will be accomplished at the same time as the mate operation. This will be an initial alignment of stage and engine center lines. Additional alignment of the S-N stage as part of the Saturn VN Launch Vehicle will be accomplished in the VAB. Interface and engine system checkout follows engine mating. The engine will be pressurized and interface connections will be checked for leakage. Continuity checks of electrical connections will be made followed by an engine system functional check with the stage propulsion system integrated with the engine propulsion system, an overall propulsion system check will be performed.



*MAY BE ACCOMPLISHED FROM THE UMBILICAL TOWER
**FLSC INSTALLATION MAY BE ACCOMPLISHED IN THE VERTICAL ASSEMBLY BUILDING IF THE LOADING IS 25 GROINS. FOOT OR LESS.

Fig. 6-4 Separation Subsystem

6.3.3 cont;d

Prior to simulated flight tests, an RF Compatibility Test will be conducted with all transmitters and receivers operating to check for false triggering and inter-system interference. Next, a Simulated Plug-Drop Overall Test will be performed to demonstrate the performance of all systems by programming the stage through a simulated launch count down and through a simulated flight sequence with the exception of umbilical ejection. The Simulated Flight Test will follow which is the same as the Simulated Plug-Drop Overall Test except that umbilicals are ejected.

At the completion of checkout, all cables and lines will be removed, access platforms pushed aside and the On-Site Transporter will remove the stage from the Stage Mounting Stand. The stage will then be moved to the VAB.

Section 7

LAUNCH OPERATIONS

This section will include all activity from receipt of S-N Stage at VAB to final impact. NSP personnel will participate in this activity by assisting and supporting LOC as directed.

7.1 VAB

At receipt of the S-N stage at the VAB, a visual inspection will be performed and stage records will be checked for completness. The S-N Stage with the IU and nose fairing will be mated to the stacked S-IC and S-II-FD. Alignment will be performed and interface checks will be conducted. After hooking up the stage ESE, individual stage checkout will be started using the LCC/LUT computer complex. Overall vehicle systems tests, including systems associated with control, ordnance and RF, are conducted. Overall guidance and flight control tests will include checkout of the ~~overall~~ guidance loop with booster engine controls, stage attitude control loops, booster engine response to guidance commands, engine thrust reactor alignment, power and command control transfer upon simulated stage separation. Overall RF interference, noise checks and preliminary systems calibration will be performed. Ordnance checks will include verification of stage destruct system compatibility with booster system, destruct systems response to RF commands, and demonstration of destruct initiation utilizing ordnance simulators. The final stage in vehicle checkout prior to movement to the launch pad will be a simulated flight test including all systems in the following operational sequence:

1. Countdown
2. RF checks
3. Power transfer
4. Firing command
5. Thrust buildup and simulated lift-off
6. Simulated Flight
7. Destruct
8. Nuclear Stage Shutdown

7.1 cont'd

After completion of checkout, access platforms are moved aside, pneumatic, hydraulic and electrical lines connecting the LUT to the VAB and LCC are disconnected. The crawler-transporter moves into position under the LUT, raises it and moves it out of the VAB over the Crawlerway to the launch pad.

7.2 ARMING TOWER

After leaving the vehicle/LUT at the launch pad, the Crawler Transporter will pick up the Arming Tower and bring it to the Launch Pad. Installation of flight ordnance and pyrothechnics will be accomplished using the arming tower to include the following: flexible linear shaped charge and mild detonating fuse - stages and interstages; separation initiators - payload; stage, reactor destruct charges, charge jettison device, destruct initiators - first and second stage tanks; LH_2 tank; reactor safety system - retro-rockets.

Squib activated valves for the LH_2 system and reaction control system are self-contained devices and will be installed during stage assembly operation.

Shorting plugs will be installed in all electrical initiators to prevent accidental detonation. No voltage checks and final electrical hookup will be accomplished, manually or remotely, on the pad during the launch countdown.

7.3 LAUNCH PAD

Following Arming Tower activity, vehicle checkout at the Launch Pad will continue. Following satisfactory checkout verification of each major subsystem, a final, brief computerized integrated systems test will be performed on the total launch vehicle. Major objectives of the test will be demonstration of external and internal power operation and transfer capability, flight termination system, rf radiation, and emergency hold and recycle capabilities.

At the conclusion of the test, all data will be examined, analyzed, and evaluated by MSFC-LOG and the contractors prior to the initiation of any countdown activity.

First stage fueling and programmed water ballasting of the second stage may be completed prior to initiation of the final countdown activity. An integrated master countdown procedure will provide a chronological sequence of events necessary for the launch of the RIFT vehicle. ~~as outlined in Fig. 12-8.~~ Personnel actually performing the work will work to detailed check lists noted in the master countdown procedure. A brief outline of major master countdown tasks follows:

(1) Task 1 - Countdown Initiation

During this period, verification will be made that all precount activities have been completed and all personnel required to support the launch activity are on station. A communications systems test will be made of the facility as well as supporting tracking stations, picket ships, and aircraft involved in range operations. A typical check list of launch configuration verifications follows: all umbilicals mated and rigging complete; flight batteries installed and connected; no open items in the vehicle or facilities inspection books; fire and emergency equipment manned and on station; launch control center clock synchronized with WWV; all arming plugs on test conductor's board; telemetry ground station on and aligned; Range Safety destruct signal generator keys are on the key panel; and computer programmed for firing systems test.

(2) Task 2 - Electronics Warm-up and Subsystem Checkout

During this period the external power supplies will be turned on and regulation verified. Console operators will turn panel power on and report readiness to the Test Conductor. Firing systems tests will be conducted. Telemetry destruct/command receivers, Mistram and C-band beacon will be turned on. Guidance power will be turned on and thrust deflector zero checks conducted. Preliminary gimbaling will be performed and roll, pitch, and yaw control verified. Subsystems checkout will be conducted per detailed check list procedures.

All systems will satisfactorily complete preliminary checkout. Test data will be reviewed by the NASA test director, the booster stage test controller, and the Lockheed launch controller. Satisfactory performance of all systems tested to this point will be "go" indicator to proceed with the countdown.

(3) Task 3 - Ordnance Connection

To be supplied later.

(4) Task 4 - Reactor Arming

The reactor arming crew will conduct no-voltage tests on the reactor drum control circuits and the ground initiation circuits for the reactor destruct system. The actuator control circuits will be connected electrically. Control drums will be rotated one (gang) at a time for mechanical calibration and actuation verification. Drum checks will be completed. The in-flight removal mechanism for the nuclear engine safety wires will be hooked up and checked as necessary. The core destruct ground initiation circuits will be connected and the nuclear stage access door secured. When all nuclear preparations have been completed in accordance with AEC requirements, the LH_2 system will be purged ~~with GN_2~~ and preparation completed for tanking the LH_2. The umbilical tower will be secured for launch and the area cleared of all personnel. Pad safety will verify that the area is clear and notify the test conductor that the reactor destruct circuits may be armed and LH_2 transfer operations may proceed.

(5) Task 5 - Reaction Control System Pressurization and LO_2 Tanking

The self-contained systems will already be filled with UDMH fuel and nitrogen tetroxide oxidizer. The pressurant tanks will be filled with gaseous nitrogen. During this period, the LO_2 system will be purged with inert gas and preparations for LO_2 transfer completed.

The digital master computer at the LCC has direct control of all activities from this point. The GH_2 accumulators will be charged. The pad area will be cleared and LO_2 tanking, guidance-flight control loop tests will be completed.

(6) Task 6 - Final Systems Verification

The reactor destruct system is armed. The LH_2 chill-down operation started. All systems are turned-on for final checkout and verification. Final guidance-flight control loop tests are conducted. Range readouts are recorded for Mistram, beacon, telemetry, and destruct/command systems. Destruct checks are conducted on internal power.

(7) Task 7 - Launch Terminal Countdown

During this period, final launch preparations will be completed. All systems will be turned on and range verification received. Final guidance checks will be accomplished. Transfer of LH_2 will be completed and booster and nuclear stage tanks pressurized for flight.

7.4. FLIGHT

Operations of the nuclear stage will start approximately 30 sec before separation from the booster stage. Prior to separation, the stage sequenced operations will involve a change in tank pressurization, de-safing of control rods, and nuclear-engine initial start to approximately 1-percent power level. A typical flight sequence of events from launch through impact for a RIFT vehicle is shown in Table 7-1.

Power level for nuclear operation will be controlled by an onboard programmer. In addition to normal Range Safety commands, the Launch Control Center will have the capability of commanding nuclear engine start, and will have a nuclear engine override shutdown command capability. This will be accomplished by the digital command system.

7.5. NORMAL FLIGHT TERMINATION

The intended area of flight termination is in deep ocean water beyond the Continental Shelf. The ocean depth at the intended impact area is approximately 3,000 fathoms. The nuclear stage will descend on a ballistic trajectory following nuclear-engine shutdown, and will disintegrate upon atmospheric reentry. However, the nuclear engine may impact essentially intact, and the possibility exists for a nuclear excursion following impact and water imersion. Therefore, the following criteria apply to normal flight termination:

a. The area for intended impact will be in deep ocean water.

b. Areas of possible impact will be cleared of ships.

c. The BOA Hydrophone Network for impact location and range tracking equipment, and S-N stage associated equipments - such as SOFAR bombs, beacons, and transponders - will be operative for the tests.

d. The ocean area near the impact point will be monitored and

TABLE 7-1

TYPICAL FLIGHT SEQ. OF EVENTS

1	S-IC Ignition
2	Liftoff
3	S-IC Pre-Depletion Signal
4	Initiate Safety Wire Removal
5	Start Engine Power Buildup Program (0% - 1%)
6	S-IC Thrust at 10% Level
7	S-IC Shutdown Backup Command
8	Initiate Separation Device
9	Ignite Retro-Rockets
10	G and C Switchover to RIFT Stage
11	Open Propellant Tank Isolation
12	Start Power Buildup 1% - 100%
13	Pressurize Ullage Rocket Subsystem Tanks
14	Open Attitude Control & Ullage Rocket Subsystem Isolation Valves
15	Physical Separation Detection
16	Increase Propellant Tank Pressure (by means of bleed gas)
17	De-activate Pre-operational Reactor Destruct Device (dependent on AGC studies)
18	Activate Thrust Vector Trim System
19	Start Attitude Control Program
20	Hold Constant Inertial Attitude
21	Steady-State 100% Power Achieved
22	Change Gains in Attitude Control Rockets Subsystem
23	Start Controlled Shutdown Program
24	Close Propellant Tank Pressurization Valve
25	Change Gains in Attitude Control and Ullage Rockets Subsystem
26	Turbopump RPM Reaches Cooldown Free-Wheel Valve
27	Maintain Propellant Tank Pressure
28	Post-Criticality NERVA Destruct (dependent on Further-AGC studies)

surveyed to determine the time history of fission product concentration. Shipping and fishing will be restricted until the safety of such activities has been established.

Section 8

Post-test Operations

Post-test operations will include all test-related operations that occur after final impact of the nuclear stage. These operations include pad refurbishing, radiation monitoring, impact-area surveillance, and emergency procedures.

Most of these operations are affected by nuclear radiation problems. Continuing effort is being given to this area through Nuclear Safety studies; therefore, discussion in this section will be delayed until later in the program.

Section 9

FLIGHT EVALUATION AND REPORTS

9.1 RESPONSIBILITIES

The NSP~~O~~ ~~base~~ stage test manager will be responsible for flight evaluation at test base level, for supporting the collection, processing, and flow of data to the Test Operations Directorate, for preparing flight reports, and for providing preliminary reports of flight operations to the NASA Launch Directorate.

9.2 FLIGHT EVALUATION

Evaluation of the flight tests will be accomplished by NSP~~O~~ program management, engineering, operations, and research personnel. Documents to be used as a basis for the evaluation are the following:

- Flight Objectives
- Test Requirements
- Measurements List
- Instrumentation List

The evaluation will utilize data generated during the tests. The sources of data at the launch base are:

- Telemetry
- Radar

9.2 cont'd

- AZUSA
- Optics
- Engineering Sequential Films
- Engineering Documentary Records

9.3 [redacted] TEST DATA

Test data will flow from the launch base to NSP[redacted] program management and engineering in accordance with existing procedures and data processing equipment capabilities at LOC [redacted] and at LMSC. Accordingly, optical, radar, and AZUSA data will be reduced by RCA at AMR and provided to LMSC. Also, technical and documentary film will be processed at AMR, and print masters and copies will be provided directly to the LMSC base manager and forwarded to the Test Operations Directorate for data processing. Real-time telemetry records will be provided to the NSP [illegible] [redacted] manager and utilized for preliminary performance analysis.

9.4 ~~15.4~~ REPORTS

The preliminary reports originating at the launch base will be as follows:

- Flash Report
- Quick-Look Report

[redacted]

The Flash Report will be an early report on the performance of the flight test. It will be issued as soon as possible following launch, and will be

9.4 cont'd

forwarded to the NSP Test Operations Directorate and the NASA Launch Directorate. This report will contain information on all subsystem operation. Emphasis will be placed on areas of possible malfunction. The report will be based upon test observations, data logs, radar and optical information, and telemetry real-time records.

[redacted]

The Quick-Look Report will be provided to the NSP Test Operations Directorate and to the NASA Launch Directorate 72 hours following the launch. The Test Operations Directorate will present the report along with the Data Report prepared at LMSC-Sunnyvale by Flight Data Processing as a complete test presentation to NSP~~O~~ program management and engineering. The Quick-Look Report will cover conduct of the test, and will utilize inputs of the operations personnel in conjunction with test data in an evaluation of vehicle performance. Preparation of this report will benefit from the availability of technical and documentary film and more complete radar and telemetry information than was available for the Flash Report.

SECTION 10

SCHEDULES

The RIFT MILA milestone schedule, Figure 10-1, indicates major activity dates that must be met by LMSC and the engine contractor in order to have the stage ready for flight tests. A three months launch interval was used as a constraint in developing the schedule. Time intervals at each location were decreased with each successive stage to reflect improved techniques and decreasing revisions. It should also be pointed out that SN-1 in conjunction with SN-D will be used for facility validation. Critical schedule points are:

- Stage delivery to NAB
- Engine delivery to stage checkout area
- Stage delivery to VAB
- Vehicle transfer to pad

In addition, typical stage checkout is shown in Figure 10-2 and Figure 10-3. These figures give a more detailed breakdown of time intervals for individual checks.

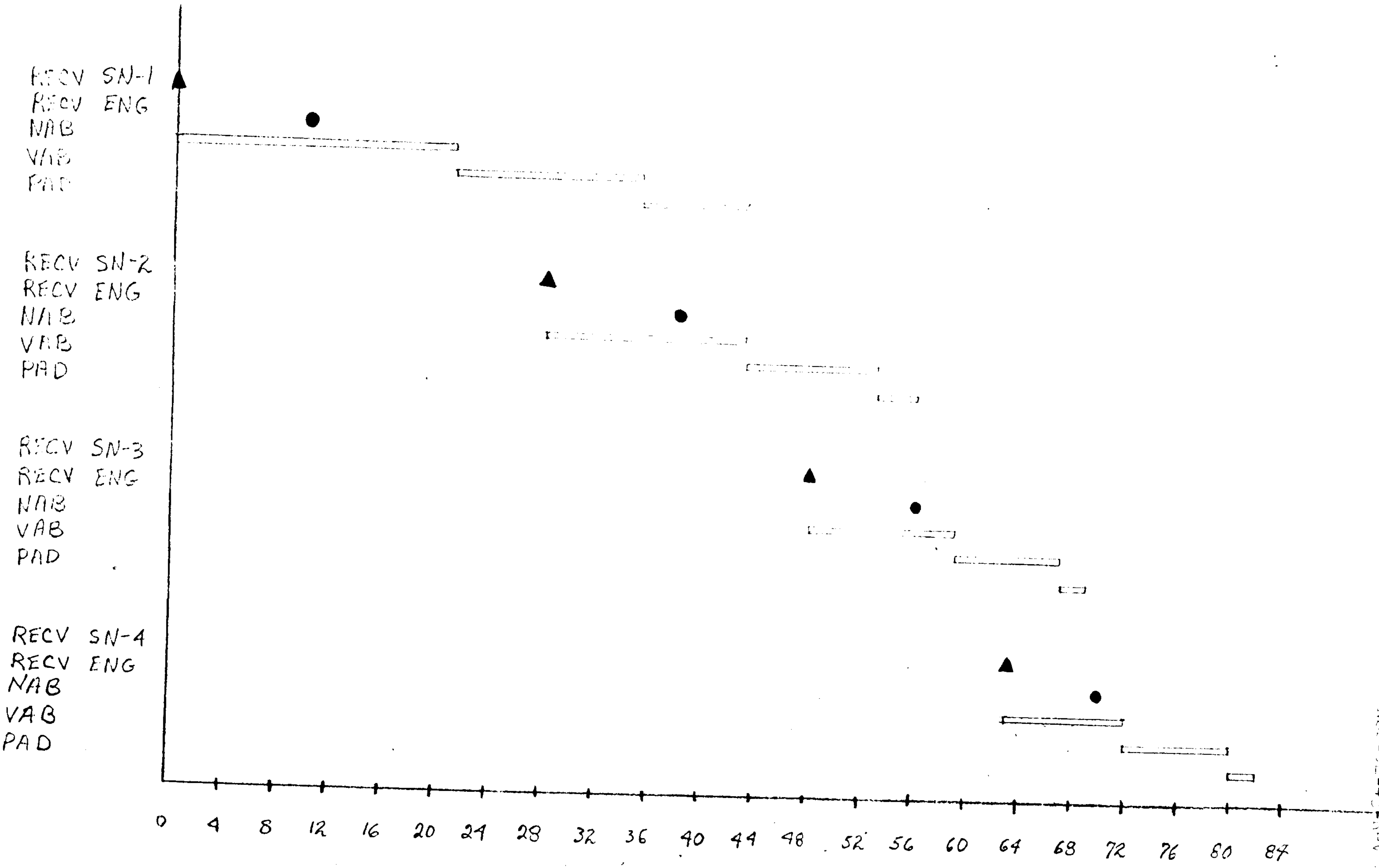


FIG. 10.1 RIFT NAB MILESTONES

FIG — 10.1

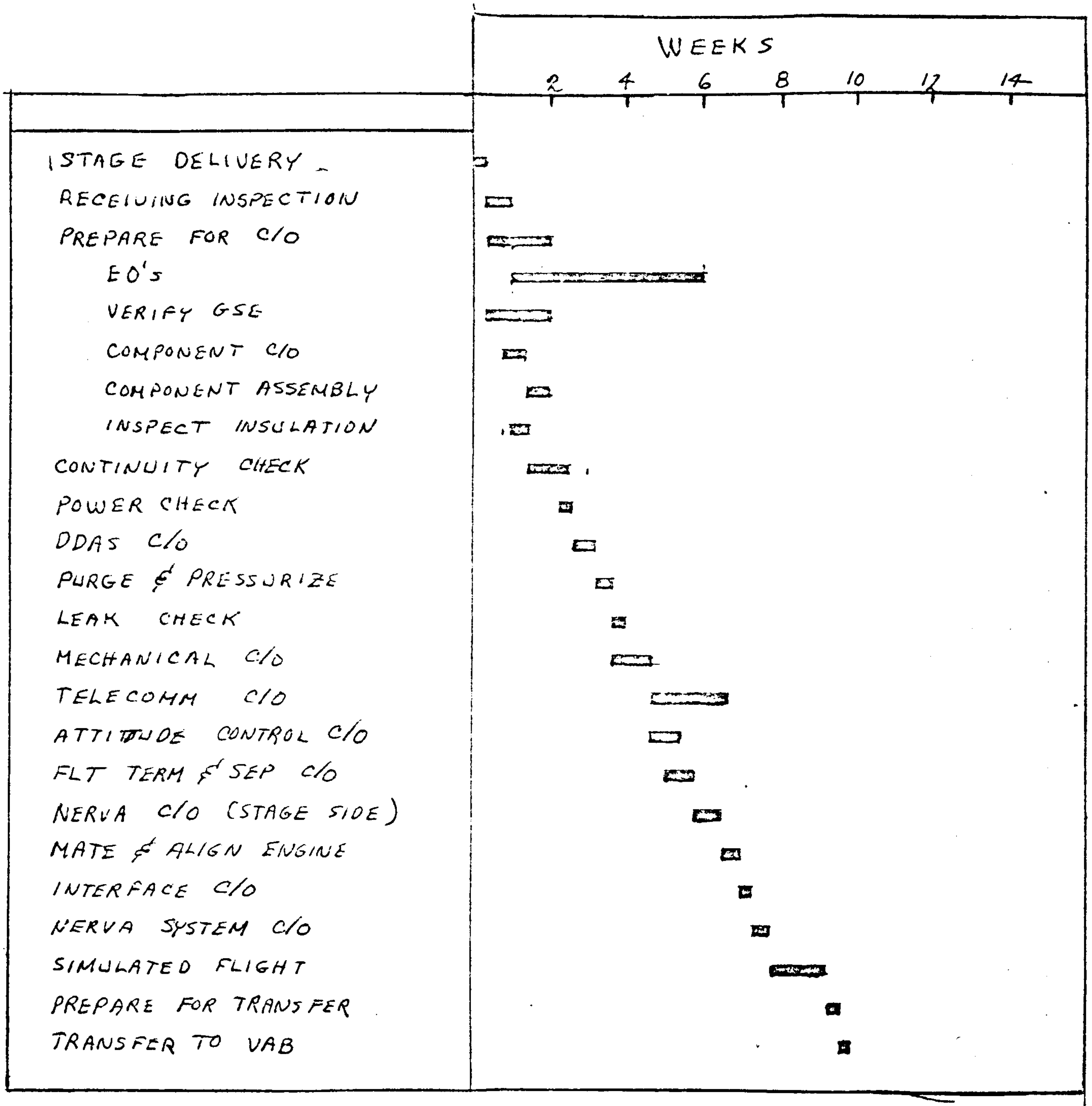
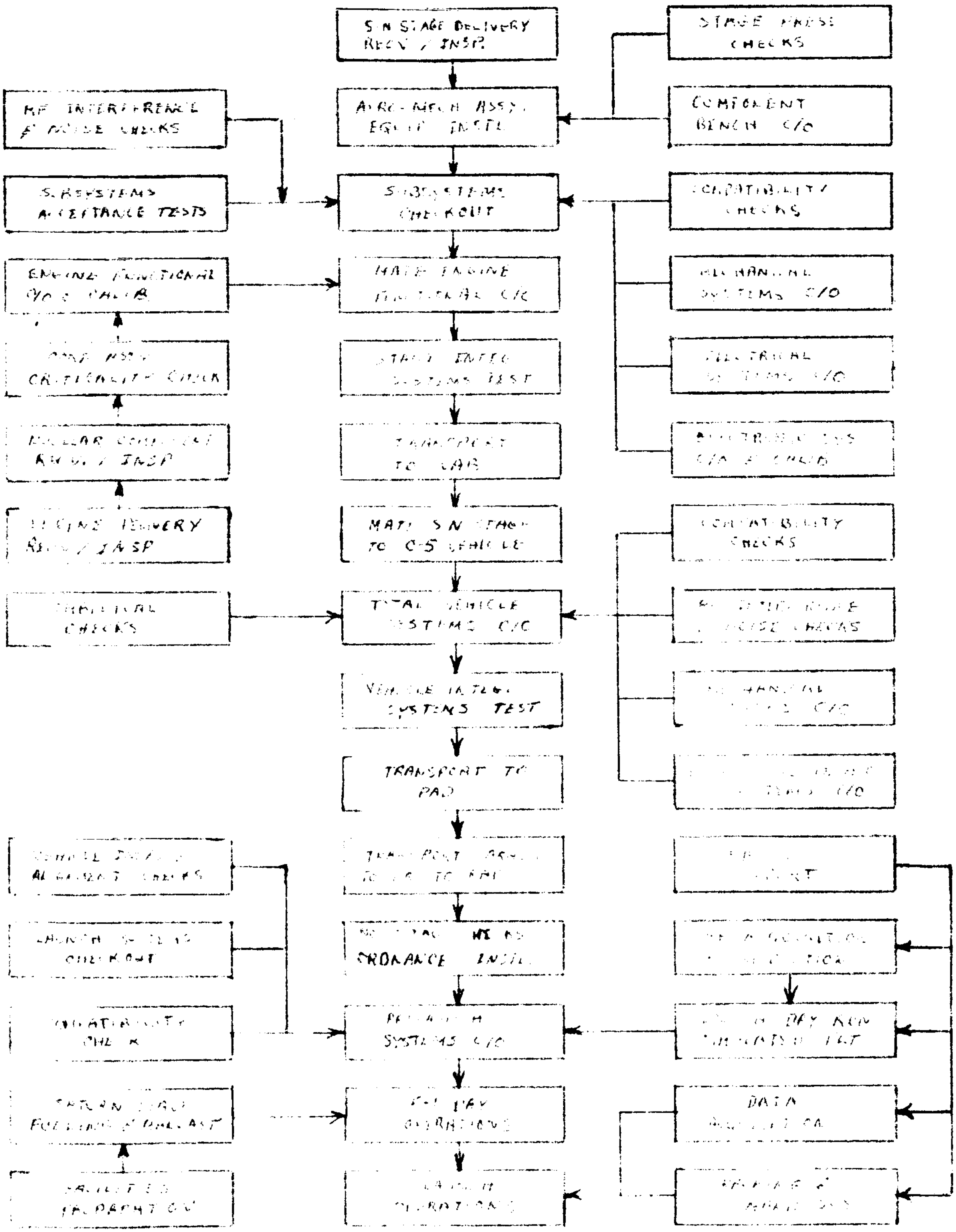


FIG. 10-2 TYPICAL S-N STAGE PROCESSING AT MILA


S-N STAGE DELIVERY RECV / INSP.
STAGE PRESS CHECKS
RF INTERFERENCE & NOISE CHECKS
AERO-MECH ASSY. EQUIP INSTL
COMPONENT BENCH C/O
SUBSYSTEMS ACCEPTANCE TESTS
SUBSYSTEMS CHECKOUT
COMPATIBILITY CHECKS
ENGINE FUNCTIONAL C/O & CALIB
MATE ENGINE FUNCTIONAL C/O
MECHANICAL SYSTEMS C/O
STAGE INTEG SYSTEMS TEST
NUCLEAR COMPONENT RECV / INSP
TRANSPORT TO VAB
ENGINE DELIVERY RECV / INSP
MATE S-N STAGE TO C-5 VEHICLE
COMPATIBILITY CHECKS
TOTAL VEHICLE SYSTEMS C/O
VEHICLE INTEG SYSTEMS TEST
TRANSPORT TO PAD
ORDNANCE INSTL
DATA

10-H

Section 11
SAFETY CRITERIA AND PROCEDURES

11.1 SAFETY CRITERIA

In all phases of the test base operation, safety shall be considered as paramount in importance. At no time during the test base operation will conditions be allowed to exist or work proceed which would lower the level of safety under that specified in the program.

Safety is accomplished only by careful attention during the design phase to factors which control the operational phase. The design of all vehicle hardware, support systems, and facilities will be continually evaluated by personnel having extensive experience in test base operations and nuclear, and cryogenic, as well as industrial safety to assure realization of maximum safety and protection during the operational phase of the program. A test base safety organization will be responsible for implementation and monitoring a safety program aimed at providing maximum protection to personnel and property according to policies established by the NSPO director of test operations.

11.1.1 Nuclear Safety Criteria

The RIFT program will conform to the radiation safety standards required by the AEC, NASA, Range Safety, USAF, and applicable federal, state, and local regulations.

11.1.1 cont'd

Biological effects to large population groups from the radioactive material produced by normal or abnormal launch operations through direct exposure via food chains or other processes, in terms of somatic or genetic effects, will be small compared to that from radioactive material presently in the environment.

Credible accidents in the RIFT operations will not result in radiological exposure risks in excess of those from other reactor programs, for either operational personnel or the general public. RIFT launches will not significantly diminish the safety presently afforded for the launch of non-nuclear vehicles.

The reactor will be kept inoperative until programed to start in flight. poison safety wires will be removed during the first phase of flight after deep water impact is assured. In-flight startup shall not occur unless first stage performance is normal.

A safety system included will be capable of rendering the reactor safe in the event unsuccessful flight leads to impact in an area endangering operational personnel or the general public.

Radiation exposure criteria for RIFT operations will be based on the radiation protection guides in 10CFR20 and amendments recommended by the Federal Radiation Council and permissible exposures recommended by the National Committee on Radiation Protection and the International Commission on Radiological Protection.

11.1.2 Non-Nuclear Safety Criteria

The industrial and cryogenic safety procedures established for use on the RIFT program will be in accordance with AFM 32-3, the basic USAF safety publication, and such other publications, pamphlets, regulations, and technical orders relative to missile handling, hazards, fueling, health hazards, ordnance etc., which are directive in nature and applicable to and binding upon all agencies at AMR.

11.2 SAFETY PROCEDURES

11.2.1 General

A comprehensive safety program will be established to provide specific regulations and procedures governing personnel protection; work area protection, including off-site protection; operational safety; emergency procedures; and program implementation.

In all phases of the operation, safety of personnel will be the first consideration. Under no circumstances will work be permitted to proceed with the knowledge that safety requirements have not been met or complied with.

11.2.2 Personnel Protection

In addition to the equipment normally associated with industrial and cryogenic safety, special nuclear safety devices and equipment will also be provided.

11.2.2 cont'd

All workers at the test base whose duties require entry into restricted areas where possible exposure to radiation exists will be required to wear film badges. These devices provide a relatively accurate means of determining dosages received from beta and gamma radiation and have an advantage over pocket ion chambers in that they provide a permanent record of both quantity and type of radiation received. Special emulsions sensitive to neutron radiation are available and will be used as prescribed by the nuclear safety staff.

Personnel working in areas where there is a possibility of exposure to high levels of radiation will be required to carry pocket dosimeters. These self-reading instruments have the advantage of immediately indicating acquired dosage; thus, the significance of the exposure can be promptly evaluated. Positive evidence of exposure for record purposes will be maintained by developing of worker's film badge.

Certain operations such as engine assembly or disassembly may subject the worker's arms and legs to higher radiation dosages than the rest of his body. Along with special protective equipment, specially designed dosimeters for hands, fingers, and feet are available and should be worn by workers requiring them. Anti-contamination clothing will be provided to workers in the engine assembly facility and other areas where operations involve danger of contamination of clothing. Change areas equipped with monitoring and disposal facilities will be located convenient to work areas.

11.2.2 cont'd

NAB

A medical first aid unit maintained in the [redacted] will be equipped and staffed to provide emergency treatment of industrial, cryogenic, or radiation accident victims. In addition, emergency aid kits will be located at selected stations throughout the site.

NAB

Included in the [redacted] will be a laboratory for issuing and processing film badges, anti-contamination clothing, and other special equipment needed for personnel safety and radiation detection.

Records will be systematically kept to provide complete and accurate information on personnel exposure histories, training completed, and other data which may be required from a health qualification or legal standpoint. A review system will be established to alert employees and supervisors of their exposure status. Records for visiting personnel will be forwarded to their home offices to insure that cumulative exposure records at different bases are accurate and up to date.

11

11.2.3 Work Area Protection

All buildings at the test base will be designed and laid out to provide the maximum safety to personnel using them. Included in their design will be protection from fire, explosion, and nuclear radiation.

Although certain buildings and areas normally will not have radioactive materials in or near them, certain precautions will be taken to see that no radiological hazards are accidently introduced. In general, these precautions

11.2.3 cont'd

will consist of strategically locating in each building one or more airborne dust monitors fitted with audio alarms to warn personnel in the area should an excessive airborne contaminant build up. Periodic inspection with portable counters will be conducted to insure against long-time build up of radioactive materials.

Areas containing fissionable or radioactive material will be controlled to limit access to authorized personnel only. These areas will be equipped with extensive detection equipment (including criticality monitors) that constantly monitor each area at several locations including air intakes, exits, and exhaust systems. These fixed systems will be augmented by the use of portable instrumentation during the conduct of hazardous tests or operations or during other periods of high danger.

Portal monitors will be installed at the exits to all controlled areas to insure that no radioactive particles accidentally adhere to personnel or material being removed from the area.

In the event of a power failure, all primary detection and alarm devices will automatically switch to emergency battery power or diesel driven generators.

During normal operations, the nuclear engine and reactor area will be the area requiring the greatest control. All personnel entering this area will be required to wear film badges. Anti-contamination clothing and special dosimeters will be required for workers handling or working near the reactor. The reactor work area will not incorporate a sprinkler system which could flood the reactor and cause an excursion.

11.2.3 cont'd

During the time that the nuclear propulsion system is present in the [redacted] NAB ~~building~~, the stage assembly area will be considered a controlled area. Workers entering this area will wear film badges even though the reactor will have sufficient poison in and around it to prevent an excursion.

The presence of the nuclear stage in the [redacted] VAB, [redacted] or at the launch pad represents a potential hazard, but because of the limited nature of work to be accomplished on the nuclear system, and the safeguards present, the exposure danger is considered extremely low. The areas will be considered as controlled areas, but film badges and other special equipment will only be required for workers requiring nuclear stage access. Monitoring equipment will be present at all times in the vicinity of the reactor to sense any increase in radiation levels and activate suitable alarms. Hydrogen sniffers in the engine interstage area and equipment bay will warn of possible explosions which could lead to a nuclear incident.

11.2.4 Protection of Off-site Personnel and Areas

The possibility of a catastrophic failure of the booster or premature activation of the nuclear engine requires that a comprehensive plan be created to protect personnel and property away from the test site. This plan shall consist of: (1) dispersion area studies based on statistical and local wind and weather conditions, (2) location of detection equipment in the dispersal area and plans for activating it during hazardous operations, and (3) evacuation plans for hazard areas should the need arise.

11.2.4 cont'd

Although final evaluation must await completion of detailed hazard studies, information from preliminary hazard studies indicates that off-site personnel and the general public will not be exposed to risks greater than those now associated with the launch of all-chemical rockets.

11.2.5 Operational Safety

All operations to be performed on the nuclear stage or its components will be in accordance with clearly written procedures and check lists. These procedures may be in the form of planning operation sheets, test and checkout procedures, countdowns or other specialized procedures involving qualified personnel and equipment. They will be originated by the responsible engineerand and operations groups and will be reviewed by the safety organization prior to approval for use. Deviations from procedure must be approved by appropriate management personnel.

Nuclear Reactor and Engine. Of all systems in the S-N stage, the nuclear reactor can be considered as potentially the most dangerous, not alone because of the risk to operating personnel, but because harmful effects from catastrophic events can spread over much wider areas and endanger more people. For this reason,a broad nuclear safety system approach has been adopted.

Among safety systems being considered, which may appear in equipment and procedures throughout operations from engine assembly through completion of flight tests, are:

- Poison safety wires for the nuclear core

11.2.5 cont'd

- Engine control drum interlock
- Engine programmer interlock
- Inert gas purge system
- Propellant isolation valve
- Prelaunch radiation monitoring
- Reactor destruct system

All work on the nuclear engine will be accomplished in the engine assembly area except for mating of the engine with the nuclear stage and stage checkout. Employment of the nuclear safety systems by facilities is indicated in Table 11-1.

Table 11-1

NUCLEAR SAFETY REQUIREMENTS

Function	Engine Assy Area of NAF	Vertical Assembly Building	Launch Pad	Nuclear Assembly Building
Subcritical Check	Yes	No	No	No
Criticality Check	Yes	No	No	No
Confinement	Yes	No	No	No
Safety Wires	No	Yes	Yes	Yes
Control Rod Locks	No	Yes	Yes	Yes
Radiation Monitor	Yes	Yes	Yes	Yes
Destruct-Reactor	No	No	Yes	No
Neutron Source Install	Yes	Yes	Yes	Yes
Isolation Valve	-	-	Yes	-

11.2.5 cont'd

<u>Nuclear Stage.</u> The nuclear stage assembly and checkout can be considered in two phases. The first phase would include all work scheduled for completion prior to the mating of the nuclear engine. During this phase the greatest dangers lie in missile fires involving electrical systems and the safety program to control operations and safeguard personnel would very closely parallel those presently in force on the Agena, Polaris, and other Lockheed programs. As previously stated, all work would be conducted per approved procedure to minimize accidents caused by procedural errors.

The second phase would begin when the nuclear system is delivered to the stage assembly facility. At this time all systems checkout will have been completed except those items requiring the nuclear system for completion. During this phase the assembly area will be considered a radiation controlled area and all workers will be required to wear film badges. Special dosimeters and protective clothing will be required for workers handling the engine during mating and checkout operations. At no time will the poison be removed from the reactor in the NAB. [redacted]

<u>Flight Vehicle.</u> The final assembly of the launch vehicle will be accomplished in the vertical assembly building. By this time, checkout of the nuclear stage and booster stages will have been completed. As in the NAB, [redacted] a controlled area must be established when the nuclear stage is delivered to the vertical assembly building. However, because danger of radiation exposure is extremely unlikely in this facility, only those persons requiring direct access to the nuclear stage will be required to wear film badges. No relaxing of requirements to monitor the area for radiation hazards will be permitted.

11.2.5 cont'd

It is conceivable, and even quite probable, that engineering modifications or component failures may require rework to the nuclear engine assembly or surrounding systems during the time the system is in the NAB, vertical assembly building, or area other than the engine facility. Prior to accomplishment of such work, cognizant technical and safety representatives of affected contractors will consider the risk involved and take appropriate action to assure adequate safety even though such action may require return of the engine to the engine assembly area. In no instance will schedule considerations be allowed to compromise safety.

Handling and Transport. The handling, storing and transporting of vehicles, materials, or components including nuclear and cryogenic materials will conform to the safety standards as required by the AEC, NASA, Range Contractor, USAF, and other applicable federal, state and local regulations. To insure that such a program can be met, a system of inspection and maintenance of all LMSC controlled equipment will be enacted for all equipment associated with the handling of men or material. Operation of such equipment will be restricted to trained and competent operators.

Launch Pad Safety. Prior to delivery of the vehicle to the launch pad, the Range Contractor will perform a comprehensive inspection of the test stand, launch site area, fuel systems,water systems, camera pads, propellant storage areas, pressurization and distribution system, and emergency diesel equipment. The facility must be certified as ready to support the pre-count activity.

11.2.5 cont'd

All precount activity shall be done in accordance with a master vehicle preparation procedure which shall list all work to be accomplished, persons and contractors responsible, applicable procedures involved, and safety plan in effect. Safety plans will define the personnel, equipment, and controlled area requirements for each operation to be performed.

Range Safety. Certain hazards not associated with all-chemical rockets are inherent to the launch of a vehicle incorporating a nuclear reactor. These hazards involve the radioactive contamination of air, land, or ocean areas in the event of a catastrophic failure of the system. Extensive hazard analysis must be made before a complete evaluation can be made; however, it is apparent from preliminary studies that adequate safeguards can be effected to reduce the risk to the level presently associated with the launching of large chemical rockets.

Presently under consideration is a reactor destruct system. Initiation of the vehicle destruct system [redacted] by command of the range safety officer [redacted] shall rupture the main tanks of each stage and explode a series of charges surrounding the nuclear reactor. These charges would cut the reactor elements into pieces of less than critical size so that no danger of an excursion will exist on impact. Following nuclear stage separation the reactor destruct charges would be jettisoned to prevent auto-detonation due to radiation heating. As a further safeguard the reactor start signal would be locked out until certain conditions of time, acceleration, and attitude would have been satisfied.

11.2.5. cont'd

Although the probability is considered extremely remote, certain failure modes can occur which would result in a reactor excursion following impact on a land mass or in relatively shallow water. Remote operated equipment is therefore necessary to permit either land or water recovery of radioactive rubble. Inasmuch as all impact points for flight aborts subsequent to the programmed initiation of the nuclear stage are in deep water, no hazard from radioactive rubble is anticipated and no recovery is felt necessary. Contamination of food supplies through fishing activities in these waters is considered small although some restrictions may be advisable in the event of a shallow water impact.

Tracking information to provide real-time data on vehicle attitude and predicted impact will be provided through Azusa, FPS-16 C-band radar, Skin Track radar, electronic sky screen equipment, and optical sky screen. Destruct action will be taken by the range safety Officer whenever trajectory directions or predicted impact point violate the boundaries established for safe flight.

11.2.6 Emergency Procedures

The basic safety policies of LMSC dictate that hazard conditions resulting from all credible accidents be covered by emergency procedures clearly defining the responsibilities of employees, their stations and duties, evacuation plans if applicable, and the type of alarm to be given. These procedures will closely parallel those presently in effect on existing missile programs for facility or missile system fires, cryogenic mishaps, transporter accidents, launch aborts, etc., except that allowances must

11.2.6 cont'd

be made for the presence of a nuclear reactor. Extensive analyses will be made to establish the hazard areas for each credible accident situation involving the nuclear reactor which exposes or threatens to expose workers to harmful radiation. Evacuation plans will provide for the prompt removal of all non-essential personnel from these areas until the hazard has been removed by trained emergency crews.

Particular attention will be given to those accidents which involve a reactor excursion caused by land or water impact due to an aborted flight in which the destruct system fails to destroy the reactor core. Areas which are endangered in this manner must be evacuated prior to launch. Trained crews will be standing by with suitable equipment for emergency action dictated by these accidents.

11.2.7 Committees and Implementation

The NSP test operations director will create such committees as are appropriate to insure the creation and implementation of a complete operational safety program. Members will include qualified representatives of engineering, operations, and management.

An intensive training program will be conducted to indoctrinate all workers with the hazards of their jobs, the use of safety equipment, and their functions and responsibilities in the event of an emergency in their area. Satisfactory completion of the safety training will be required before personnel can be authorized to perform or supervise work involving hazardous systems in the vehicle.

11.2.7 cont'd

Periodic inspections will be conducted to verify the condition of equipment, conformance to regulations, and the existence of hazards.

The entire safety program will be rigidly enforced by the NSPØ test operations director. Violations will be dealt with promptly and disciplinary action consistent with company policy taken to insure mandatory adherence to the program.

11.2.8 Special Precautions

Hazards and handling problems unique to the RIFT program are largely the result of having a nuclear reactor in the RIFT stage. They require special precautions to reduce the risk to operating personnel and the general populace. In general, such precautions fall into three classes: elimination of hazards, control of risks associated with the hazard, and education and training.

Hazard Studies. In keeping with Lockheed policy, complete and thorough analysis shall be made of all phases of the flight test program to determine possible failure modes, nature of incidents, and operation plans. The special precautions to be taken at the test base will fall into the operational category and shall form the foundation of the safety program.

Elimination of Hazards. Many hazards can be eliminated or significantly reduced during the design phase of the program by careful attention to design details. Qualified personnel shall review all vehicle and facility designs to insure that no operational problems are built in and that all test and handling requirements can be satisfied.

11.2.6 cont'd

Control of Risks. Obviously all hazards cannot be eliminated. Therefore, after achieving what reductions are possible, controls must be established which will reduce the probability of occurrence to acceptable levels. These controls shall be of the following nature:

- Procedural controls: all operations will be per approved procedure and/or preplanned workbook items. Radioactive or fissionable material shall be handled on a controlled inventory basis. Inspection and monitoring shall assure conformance to procedure.
- Area control: area controls will be established to provide safeguards from fire, explosion, radiation, and sabotage.
- Safety equipment: personnel involved in hazardous tasks shall be provided with safety equipment fitting the operation. Typical examples are anticontamination clothing, radiation detection badges, breathing equipment, safety glasses, etc.
- Safety systems: airborne safety systems will encompass command ~~and autodestruct~~ of missile stages and reactor core, interlocks to prevent premature reactor activation, and reactor poison to prevent accidental excursions. Ground safety systems will include area monitoring equipment, alarm systems, sprinklers, decontamination equipment, tracking and destruct systems, etc.

Education and Training. To insure the effectiveness of the controls established for the test base operation, an extensive program of education and training must be conducted. All personnel at the base shall be indoctrinated in the

11.2.8 cont'd

hazards involved in their work and their responsibilities in minimizing risks. All operating personnel shall be thoroughly trained and qualified in their work.

In addition to direct training of operational personnel, LMSC shall cooperate fully with NASA, Range Contractor, and associated contractors in establishing and conducting a public awareness program aimed at alleviating or preventing misconceived ideas of hazards by the general populace. Such a program will reduce the danger of panic in the event of an aborted launch and reduce the danger of creating undue public concern.

Section 12

RANGE SUPPORT

The detailed requirements for range support will be included in the Program Requirements Document to be issued at a later date. General range support requirements are as follows:

- Standard timing reference to correlate data from nuclear vehicle, aircraft, shipboard, and ground systems (WWV)
- Launch and ascent optical, radar, and telemetry coverage
- Accurate data on wind speed and direction
- BOA hydrophone network to determine nuclear engine impact point from SOFAR bombs
- Instrumented ships, aircraft, and downrange ground stations for acquisition of midcourse and reentry-phase data
- Integrated communication system of landlines and radio links
- Range safety and command control

Section ~~10~~ 13

AMR ENVIRONMENTAL CRITERIA

The S-N stage is being designed in accordance with information in Appendix I of MSFC letter M-AERO-G-15-62 (subject: "Natural Environmental Design Criteria for RIFT Vehicles,") dated 2 August 1962. The wind conditions to which the stage is being designed also represent the maximum ground wind speed envelope for launch-pad operations and the upper wind speed envelope for the ascent trajectory. The criteria applicable to the Checkout and Launch Plan are the launch-pad wind environment and the inflight wind environment.

~~10~~ 13.1 LAUNCH-PAD WIND ENVIRONMENT

Wind data to be used for the RIFT vehicles for launch-pad (ground) wind environment will be as follows.

~~10~~ 13.1.1 Vehicle Free-Standing on Launch Pad

The RIFT vehicle, fueled or unfueled, will be designed to be structurally capable of withstanding the highest wind speed not expected to be exceeded 99.9 percent of the time during any monthly period, while free-standing on the launch pad at Cape Canaveral, Fla. (See Table ~~10~~ 13-1.)

13
Table 13-1

GROUND-WIND SPEED ENVELOPE, 99.9-PERCENT PROBABILITY OF OCCURRENCE
CAPE CANAVERAL, FLA.
(Applicable to vehicle free-standing on launch pad)

Height Above Ground Level (m)	(ft)	Steady-State Wind (m/sec)	(knots)	Peak Wind (m/sec)	(knots)
3.0	10	11.8	23.0	16.6	32.2
9.1	30	14.8	28.8	20.7	40.3
18.3	60	17.3	33.6	24.2	47.0
30.5	100	19.3	37.5	27.0	52.5
61.0	200	21.9	42.6	30.7	59.6
91.4	300	23.7	46.0	33.2	64.4
121.9	400	24.9	48.3	34.8	67.6

13.1.2 Vehicle Secured on Launch Pad

During periods when ground-wind conditions are predicted to exceed the 99.9-percent peak wind speeds (64.4 knots for heights up to 300 ft., 67.6 knots up to 400 ft.), the vehicle must be placed in a service structure or shelter, or secured in such a manner that no additional wind-loading conditions will be encountered by the vehicle; otherwise, a risk of loss due to structural failure must be assumed. Based on a 10-year record of ground wind measurements for Patrick Air Force Base and the Cape Canaveral area, the maximum wind measurement (steady-state) at 77 ft. is 50 knots. The service structure, shelters, or wind ties will be designed to withstand (while containing or securing the launch vehicle) wind loads resulting from the probable maximum peak wind speed of 108 knots (55.6 m/sec).

~~10~~13.1.3 Vehicle During Launch

The RIFT vehicle design steady-state and peak ground winds necessary to accommodate a launch capability during any monthly period 95 percent of the time are given in Table ~~10~~13-2.

~~10~~13.2 INFLIGHT WIND ENVIRONMENT

Wind data to be used for design of the RIFT vehicle for inflight wind environment are as follows.

Fig. ~~10~~13-1 and Table ~~10~~13-3 provide information on the idealized wind-speed profile envelope with respect to altitude which speeds are not expected to be exceeded 95 percent of the time during the windiest monthly period.

Table ~~10~~13-2

GROUND-WIND SPEED ENVELOPE, 95-PERCENT PROBABILITY OF OCCURRENCE
CAPE CANAVERAL, FLA.
(Applicable to vehicle during launch)

Height Above Ground Level (m)	(ft)	Steady-State Wind (m/sec)	(knots)	Peak Wind (m/sec)	(knots)
3.0	10	7.2	14.0	10.1	19.6
9.1	30	9.0	17.5	12.6	24.5
18.3	60	10.8	21.0	15.1	29.4
30.5	100	11.6	22.5	16.2	31.5
61.0	200	13.3	25.9	18.7	36.3
91.4	300	14.4	28.0	20.2	39.2
121.9	400	15.1	29.4	21.2	41.2

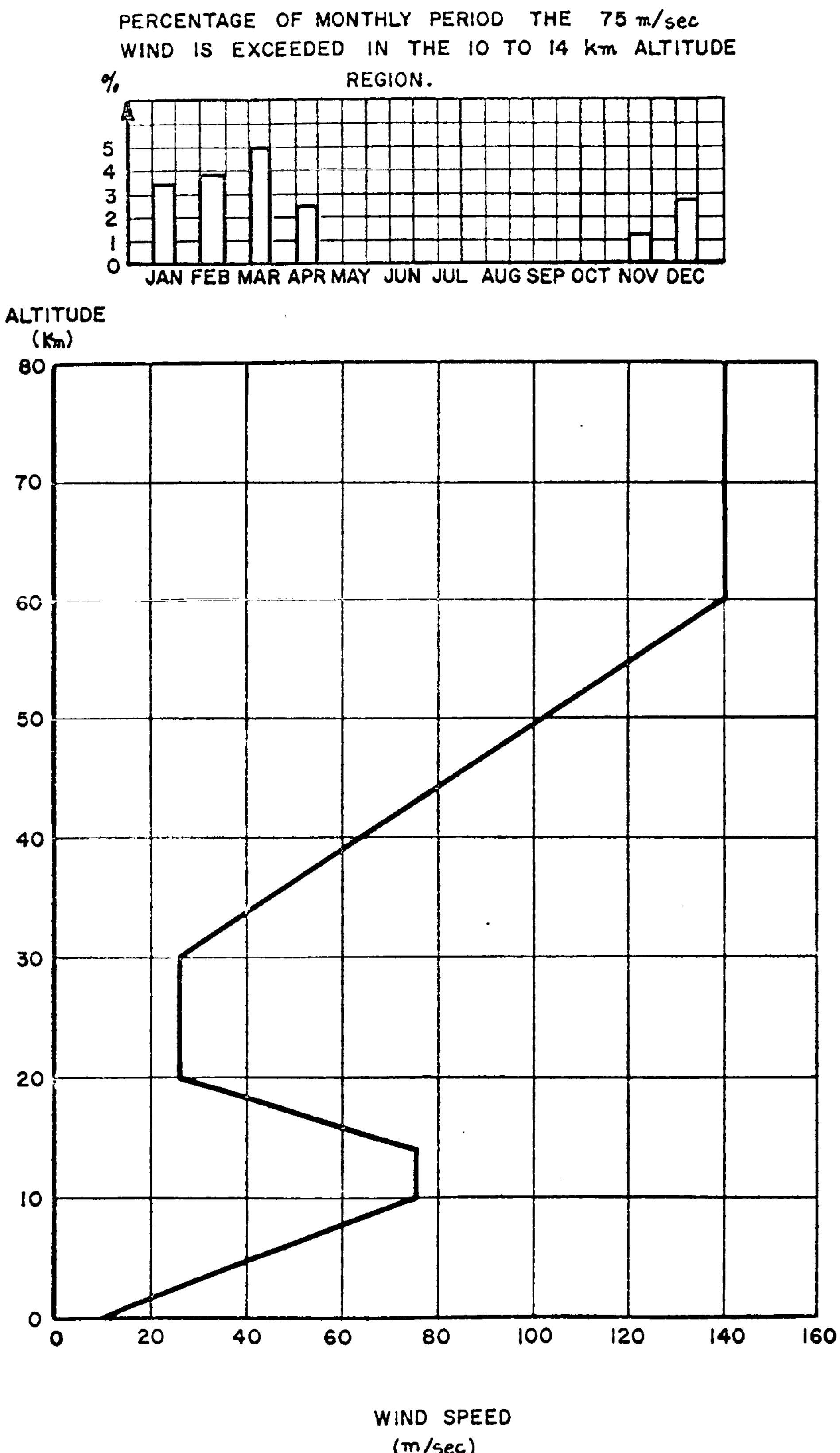


Fig. ~~10~~13-1 Wind Speed Profile Envelope

Table ~~10~~ 13-3

WIND PROFILE ENVELOPE, IDEALIZED 95-PERCENT PROBABILITY OF OCCURRENCE

(Applicable to vehicle during ascent trajectory)

Altitude (km)	Wind Speed (m/sec)
Surface	10
10	75
14	75
20	25
30	25
60	140
80	140

The windiest monthly period is defined as the calendar month having the highest average wind speeds in the 10—14 km altitude region. These data are for horizontal wind flow. These wind speeds are applied without regard to direction to establish vehicle design requirements. Since the high-dynamic-pressure region is of considerable importance for establishing control and structural requirements, the average percentage of the various monthly periods during which the 75 m/sec wind speed is exceeded has also been included in Fig. ~~10~~ 13-1 for reference purposes. This wind profile will be used for all design of RIFT vehicles.